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GLOBALIZATION: FROM CHALLENGE PERCEPTION TO S&T POLICY

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CSS/fast - 13, U.L.Businaro, *Applying S&T to Globalization issues: reflections on Globalization, complexities and problem-solving.*

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SUMMARY

The report aims at showing that a positive approach can be developed in terms of S&T policies to apply the potentiality of S&T to the globalization challenges.

The report is divided into three parts.

In Part I, the challenges coming from globalization are outlined referring to the basic features of the globalization issues, and the related geo-political and institutional problems.

The globalization process is characterized by an increase of the "density" of interactions between system elements as well as of the spatial range of the interactions (to the level of the entire world). One notes also an increase of the reactivity so that even small perturbations can have important effects at global scale and the emergence of new subsystems having global dimension. All these changes should induce a restructuring of the "global system" which, however, is far from being complete.

We are therefore faced with a basic disequilibrium that affects our ability to deal with the problems raised by the globalization process itself. There appears to be an increasing separation between the level where lays the problem to be solved from that where is the power to take actions. This disequilibrium makes even more difficult than in the past to find a just compromise between "efficiency" and "equity" in the utilization of the physical and non-physical resources to the benefit of mankind.

The corresponding geo-political scenario, far from approaching the "global village" utopia, depicts an increase in localism and mercantilism, in the separation between the riches and the poor, between those that can benefit from the S&T development and those that are excluded.

Since the globalization issues usually go beyond the national dimension, what are the opportunity to face them? The ability to decide and take actions at international levels has indeed worsened since the first decades after the second war. We are faced with a "***deficit of governance***" in an international situation which is characterized by "turbulence", by oscillations between different power regimes, between sovereign states and transnational new institutions (such as multinational companies).

A new "vision of the world" to escape from the institutional ambiguity is emerging, that of ***Regional Multipolarism***.

Notwithstanding the difficulties to manage problems at international levels, we can avail already of the results of some experience in dealing with global challenges such as the "ozone layer" case. These experience points to the importance of the role of science and science policy.

Notwithstanding the difficulties and the meager results, there is a increasing perception of the need to develop means and processes to approach issues that have an inescapable trans-national dimension.

The basic conclusion of the analysis of the globalization challenges developed in the first Part is the need to address a proper problem-solving approach.

Part II is therefore devoted to suggests a methodological approach which accepts the intrinsic complexity of globalization. The first step is to recognize that we are used to solve problem in condition of complexity. Since globalization is nothing more than a higher level of complexity we should be confident of the possibility to extend to it the problem-solving approaches we are used to when dealing with lower level complexity.

The *design* method is suggested as proper, together with the use of a *complexity wisdom* coming from our understanding and experience with complexity. A basic characteristic of system dynamics emerges: system tend to develop in a ***co-evolution*** mode (competition and cooperation) with punctuated equilibrium (system structure resists the push to change until a certain threshold of "disequilibrium" is reached).

The procedures points to: i) identify the globalization issues as disequilibria induced by the globalization process and class them at the appropriate level (local, regional or world wide); ii) define the relevant actors ("clients" and "designers") at the same level of the issue; iii) pass from the perception of challenges to problem specifications; iv) apply systematically a planning process that recognizes the importance of the bottom-up contribution of ideas and top-down definitions of objectives; v) apply the design method to develop practical solution to problems.

In Part III the possibility to approach the emergent globalization challenges by using the suggested methodology is explored by suggesting a set of actions to be taken as part of a renewed S&T policy of the European Community.

The following recommendations for actions are suggested:

- define an appropriate vision of the world, that take co-evolution as a base: the enlarged Europe scenario is proposed, where S&T could play an important role to push competition (exploit the local diversity by localized technological changes) and cooperation (increase the endowment of generic technology);
- favor the cooperation between S&T and the others social actors by developing a "policy science" that see the increase of the contribution of science to policy issues (*science for policy*). A prerequisite however is that the *policy for science* be revisited to overcome the current limits of complementarity and pre-competitiveness and of the lack of a clear definition of a "direct" client role of the EC for R&D;
- revise the R&D Framework Programme using a grids that take into direct consideration the globalization preoccupations;
- start an experimental initiative on globalization by: extending the globalization motivation to the current Framework R&D action lines; incentivating the emergence of new "clients" for globalization (Trusts, NGOs, etc.); playing a leading role for international initiatives on important matters; opening a counter to accept unsolicited proposals to help the formation of a portfolio of idea concerning globalization issues.

INTRODUCTION

The increased complexity of human affairs undermines our capacity to address and solve the problems to be faced, notwithstanding the S&T progress. There is an increasing gap between problems and solutions

Globalization might challenge the rational behaviour of operators because of new patterns emerging. Can we ***plan*** *actions* to avoid that today challenges will develop into tomorrow catastrophes of global dimensions? What methodology can support us *to pass from the perception of challenges to the definitions of derived problems* and then try to solve them?

What S&T may contribute to this process? The past successes of *planning* S&T application to difficult tasks give us some assurance. However, most of the successful cases pertain mainly to the defense and military area, where the complexity of the systems and uncertainties are artificially cut down by a hierarchical, strongly determinated decision making.

We will focus here on methodologies more than specific suggestions for actions. Some unitarian conclusions can nevertheless emerge, at least in terms of *conjectures* on globalization and of terms of reference for a deeper analysis.

We will therefore endeavor to point out a frame for first conclusions on the policy problems and the role of S&T on globalization matters and the need for EC to be concerned.

The starting point is the obvious remarks that *globalization is a real phenomenon, which produces new type of issues to which we have to respond*.

The problems related to the globalization process are impressive first of all for their ***scale***. Secondly, they are impressive for the ***systemic interdependence of the variables***.

The scale of the globalization problems suggests the need to *develop virtuous circle of wealth generation* (resources), while the interdependence suggests the need to disentangle the situations to go to the core of the problem to be solved.

Globalization requires more than ever to dedicate efforts to define the terms of the problem before trying to solve it. It blurs the *dimension* of any given problem. A problem pertaining to a class up to now considered as *local*, might - because of globalization - have shifted to a *broader dimension*. Viceversa, we might be tempted (because of the increased complexity in problem solving) to shift to a broader scale a problem that still pertain to a narrower dimension,

The *present report is aimed at showing how S&T can participate to the efforts to organize a response to the globalization challenges at all the levels* (global, regional, local) where globalization process produces effects.

Beyond technical fixes: the broader role of S&T.

How does S&T enter into the globalization preoccupations? One is tempted to follow a first direct approach: to analyze the physical problems and look for physical solutions.

If we jump right away on this concrete approach - list a set of priority issues and find solutions - we risk to be constrained within the too narrow bounds of technical fixes.

The too early definition of the physicality of the problem, might mean to have cut off the possibility to follow alternative better ways to solve it.

However, the more one departs from technical fixes, and enlarges the task of S&T, ***the less S&T can be left to the 'expert'.***

If we rightly have to enlarge the scope of S&T and to broaden the point of view, the non-linearities of the global system cannot be neglected. To define ***what*** are the globalization challenges we have to take into account the *'physical' non-linearities* (the interdependence between energy, environment, medical care, etc.). To pass to the task of ***how*** we organize to respond, we have to take into consideration more *'soft' non-linearities* (between different social-organizational subsystems).

The analysis of how we deal with emergent globalization issues confirms that the path to globalization not only asks for the solution of difficult new problems, but also decreases our confidence on the approach to problem-solving we are used to, because of: i) the increasing inability to take actions - *the governance deficit* - in a world that oscillates between world scale homogenization and multipolarity; ii) the difficulty to make a satisfactory compromise between the thrust in greater efficiency and in greater equity; iii) the antinomy of calling for an increasing S&T *generic* potentiality that should, however, result from an increasing competition through localized technological changes.

The higher the interdependence and non-linearities, the more *the problem and the process to solve it are tied together in a loop with feedbacks from problem to process and from this to problem-shifting and better focusing.* Eventually the problems to be dealt with are physical. However, we should look at them from a broader angle, before organizing the proper physical response.

Reacting to the globalization challenges by developing proper S&T policies and action programs should concern all the levels of the societal system. However, the specific roles of each level are difficult to be clearly separated. This is a further challenge of globalization. *There are loopings in the decision process at each level and feedbacks from one level to the others.*

The need to learn how to approach problem-solving.

Efforts should be devoted to 'learn to learn' how we should deal with the globalization problematique.

All our experiences in problem-solving is based on assuming that *variables can be separated*, reducing complexity by breaking it down into simpler issues.
We need therefore to include among the globalization challenges the development of a problem-solving process that fit the complex interdependences of globalization.

We might start underlining the *self-similar* (fractal) aspects of complexity in human systems: no matter how we will look at the system, from a very far away point of view (the global system appears as a 'small' whole object), or discovering lower and lower scale details using increasingly powerful magnifying lens, we will always find complexity.

The trick used in developing actions on complex system is simply to forget about the lower level complexity (that of the components of our subsystem) and that of the higher level of the system, which is taken as part of an external exogenous environment. Yet we have an internal complexity to deal with.

A prerequisite to *plan actions* is to have overcome the initial difficult phase of passing from globalization challenge to problem definition and to solution identification.

The problematique is well known to the scholars of the design process. However, usually they refer to an *individual* designer facing difficult design issues to respond to an *individual client.* Instead, dealing with globalization issues means to be faced with a ***democratic design*** *process* involving *social groups to play the roles of client and designers*.

We suggest - to deal with globalization issues - to use the same basic approach that a designer follow in inventing and developing a solution to a new problem.

The solution searching process described in the theory of design, is that of adopting a linear decision-making model subdivided into phases (problem specifications, search for a solution, acceptance and implementation of the solution), but iterating through the phases a sufficient number of times to converge on a 'good enough' result.

For a *democratic design process,* we should first stress the need to have the participation of all the society sectors to the design game. Secondly, we need to enlarge the portfolio of ideas. In fact, it would be surprising if - due to their novelty - a large enough set of proposals related to globalization issues was already on the decision table.

The consequence for S&T is the need for an urgent plan to foster the bottom-up creativity of S&T operators. However, a generic stimulus will not assure full convergence. Therefore, we have to posit top-down objectives.

To simplify, we can consider three levels of actors that enter the *democratic design* process: the political, the governmental, the operative S&T level. The respective actor's role, scope and responsibility are:

- the ***political level*** should identify the globalization issues (by analyzing challenges) and *organize the societal consensus* to deal with them. This requires to directly enter the designing phase of the problem-solving while still trying to agree on issues and objectives (*meta-design*). The outcome (considering all loopings and feedbacks) will be the definition of values, objectives, priorities, and of alternative routes to be explored in parallel;
- the ***government level*** should organize the response (*institutional design*) to the identified priorities by allocating resources to specific *'direct'* programs of action (calling for the intervention of the interested operators). It should also be concerned with predisposing a frame (norms, regulations, incentives) inducing the 'private' operators to act 'spontaneously' and allocating resources to *'indirect'* programs of action;
- the ***operative level***, and more specifically the S&T sub-level, should respond to the call for intervention on specific programmes by organizing a planned top-down response. It should also contribute to improve higher level decisions on issues and responses by feeding backs ideas and proposals.

Summarizing, the output of the iterative approach of the design method applied at each level should be respectively, i) a vision of the world in which to frame

values, priorities and to specify issues, ii) institutional buildings, resource allocations and context changing policies, iii) planning S&T actions to respond to globalization.

A scenario of cooperation and competition

A vision of the world is proposed based on the difficult balance between competition and cooperation: a scenario of macro-regions each including its share of the North and South of the world, where the difficult balance could be easier to obtain with respect to the case of a unique world region. In political terms, cooperation should focus on the need to change the common context in order to make easier to develop local responses to global problems.

The same model of cooperation/competition should apply also at the level of governmental actors to cooperate in developing new higher level institutions.

Specific policies will derive from accepting this basic dualism. Take the case of public policies to develop local technological districts. This is an intervention to favour the possibility to compete by taking advantage of local production factors that are enhanced by the cooperation that develops in the district. However, the success of the district will depend not only on the local environment, but even more so on the larger national and international environment.

The development of a scenario of cooperation/competition within macro-regions, will be an important opportunity / challenge for Europe. And on top of the list is S&T.

The barriers to respond to the globalization challenge.

Barriers exist at all levels that make difficult the development of a satisfactory problem-solving process. If we follow a linearized approach (someone set the objective, someone allocate the resources and someone else develop the solution), the non-linearities, the feedbacks, the complexity of the problem will appear as barriers to pass from one phase to the next of the solving process.

The first barriers utter at the phase of problem definition in terms of lack of consensus on what the real issues at stake are.

When passing at the phase of solving a problem on which the consensus is finally achieved, barriers might result from the resistance to pass authority to an higher level (from local, to national, to international) according to the dimensional class of the problem, to transfer resources (social solidarity) from higher to lower levels.

At the problem-solving phase, barriers emerge due to the difficulty of planning to meet specified design objectives under condition of high S&T uncertainty.

Barriers come also from the resistance of S&T communities to select general research agendas that covers fields of interest for the top-down planned actions.

What we identify as *barriers can be considered as useful signals that more iterations in the decision-making loop are needed* before attempting to proceed with next phases.

Designing S&T protocols.

The above general framework should be taken into account to design protocols for S&T policies aimed to organize the S&T response to the globalization challenges.

To be effective, the protocols should have a three levels outcome addressed respectively to the political, the governing, the operating level:

- to the attention of the ***political level***, the protocols should underline *not only a list of priority globalization issues* but also the necessity to:
  - develop a special ***alerting system*** that monitors trends and alerts on side effects (dormant issues, potential alternative outcomes from actions, need to adjourn objectives along with the progress of S&T);
  - call for a m*eta-design* responsibility which assure coherence between ends and means, between the vision of the world and the proposed routes to respond to challenges;
- to the ***governing level***, the protocols should indicate *not only a list of 'direct' and 'indirect' action* programmes, but also:
  - the appropriate procedures for existing institutions to address the different issues and the blue prints for *new institutions to be created when needed* and incentivates *the formation of networks of international research institutes on technology transfer* with patronage from governments and IGOs*;*
  - the general frame for action in term of norms, regulations, incentives to induce 'attitudinal' changes in operators' behaviour that favour the dealing with globalization;
- to the ***S&T level***, the protocols should *not only indicate the terms of reference for specific R&D programmes* to respond to the priority globalization problems but also:
  - the need to participate to the *meta-design* process with a bottom-up set of proposals and ideas to facilitate the translation of the challenges in terms of specific problems and related targets.

The opportunity for EC initiatives

The success of any policy for actions related to S&T will depend on the relationship between S&T actors and the other society actors. One way to look at such relationship is to consider S&T as an <u>offer</u> (of ideas, of services, of physical and human resources) and to ask what is the corresponding <u>demand</u> to face the S&T offer.

The effects of the non-linearity of the decision-making process (the blurring of the division of responsibilities, the needs to directly access S&T at each actor's level) make more difficult a clear identification of *clients*. One important contribution will therefore be to ***identify the client role*** of the different levels*:*

- the *political level*, for call for bids of 'conceptual' design and ideas to feed the 'meta-design' process;
- the *government leve*l, for programmes that aim at making the S&T endowment more accessible (i.e. increase its 'generic' potentiality), at developing a deeper understanding of the globalization issues, at predisposing an efficient normative standardization, and at regulating activities;
- the *operation level*, for all the programmes designed for specific intervention to change the environment and aimed at product and process innovations.

Who should take initiatives? At all levels: national, European, international. Nevertheless, it is important to underline that there is a great opportunity for the EC in this realm. Indeed, it is possible to exploit the EC ambiguity of role. It would be

an asset due to the starting confuse situations of roles and tasks subdivision among actors characterizing the globalization case. Globality mixes the cards. New roles have to be designed, new methods in decision-making to be developed.

In particular the EC has the following opportunities:

- to stimulate R&D counting on a strong leverage due to EC centrality,
- to define new issues, even very uncertain ones, profiting of the EC debate mechanism.

The Framework R&D plan can be a direct important tool, and the confrontation of ideas and the conflict of interests can help the development of new proposals.

EC can play an important role starting an experimental approach to globalization problem-solving, The very first positive impact will be that to give concreteness to the figure of *client* for globalization issues.

Part I THE GLOBALIZATION CHALLENGES

1. THE EMERGING PATTERNS OF GLOBALIZATION

The *globalization* process interests all levels of societal systems. It *effects our view of the world, our perception of values, production and trade, institutions and governments, the ways we perceive issues and organize to respond to them.* New actors emerge and old ones change their role, importance, behavior. S&T is itself *subject* as well as *object* of globalization.

Understanding the patterns which characterize the emergence of globalization in all societal sectors and in different regions of the world is a pre-requisite to discuss how we can organize a response to the *physical challenges* that accompany globalization.

In analyzing past trends we should consider not only the new problems that accompany globalization, but also the changes that globalization induces in the process of problem solving and, therefore, in institutions and actors.

There are not only problems that utter at global level. There are also processes (in dealing with problems) that develop their own global characteristics (geo-politics) and forces (determinants) that increase their span (range). Furthermore, there are actors that develop as independent subsystems.

One important aspect is to trace how the increased interactions has produced incipient structural changes in the international system. We know that we need proper actors to deal with each globalization problem. Has globalization helped in allowing new actors to emerge - especially at international level - or in solving the conflicts of competences and roles among existing ones? What patterns emerge in international problem solving capabilities?

And, furthermore, how globalization affects S&T itself? Global networks have wrapped around S&T communities. Will such globalization trends assure a better capacity to tackle the globalization needs of S&T?

Will the globalization of Science have the effect to shift the agenda of basic research towards topics more directly related to the new global challenges? What are the patterns of globalization of technology? Will a more standardized technology develop at world level, or, on the contrary, the new technological regime based on the diffusion of IT&T 'enabling technologies', will generate more adapted local responses to local market needs?

1.1 The emergence of structural changes in the world system

We cannot but feel that the state of confusion we perceive is rooted in the globalization process, since this has already produced problems to be solved, but has not yet completed the process of structure adaptation to deal with such problems.

Complex system evolution, indicates that the restructuring process is complete when a new equilibrium is reached, where each sub-system closes in itself as much as possible the cycle between problem generation and problem solving. In the case of globalization we are far from the new equilibrium.

The emergence of new global sub-systems and actors

An important question is whether or not globalization is generating new actors having 'global' dimension, or is changing the 'dimension' of old ones. The emergence of new actors might make even more problematique the ability to approach challenging issues. The emergent new sub-systems (world sub-systems) might cause an increase of system complexity and of difficulties to manage it.

It is therefore important to ask which are the new 'global' sub-systems that produce problems they are not instrumented to solve.

The ***international finance*** seems to be such a case. It has developed as a sub-system with its own dynamic behaviour, (detached from the needs to transfer money to compensate for the exchange of goods), and for which even strong intervention by national or international institutions have no practical effect.

The ***scientific community*** is another case. The diffusion of science through the diffusion of high education and research laboratories, makes more and more possible for all countries to enter into research themes which are the subject of a debate (for ethic, security or other reasons) on the need to exert some control. Who has the power to intervene?

The opening of ***global markets*** increases the need of standardization to avoid that local standards are used as a mean to close domestic markets or that stronger firms take too much advantage by imposing *"de facto"* their standards. There seems to be a dichotomy between industrial actors (individual firms) - of which only some operate at global market level (and therefore having contrasting interests regarding the problem of setting world standards) - and institutions dealing with standards (international organization which represent the 'sum' of national or continental interests). How to solve the gap?

A common problem of the 'new' global sub-systems is their lack of 'internal' control mechanism to reduce oscillations and negative induced effects on the other sub-systems (at world or lower scale levels).

The changing ranges of interaction "forces"

To grasp current and expected changes one has to look at the evolution of the interactive *forces* (***globalization forces***) responsible for the emergence of new *global sub-systems*.

Let's make some examples:

- Racial issues: racial problems tends to be of local nature. However, religious integralism, might create strong racial antagonisms even when there are no close contacts. An increase in the "range" of the racism "forces" is today apparent.
- Social solidarity: in the past, social solidarity was of short range nature. In modern state, social solidarity has become first a national issue, then an international one. The range of solidarity "forces" has evolved from local to national, European, world-wide. The media has made the world appear like a small village.

- Markets: The increased pace towards a world market for a larger numbers of products is a recent phenomenon. For certain class of products, including mass ones, we can now talk of "standard" world products. Will the trend continue and extend to other products?
- Needs & problems: an increasing number of basic needs have become "social" and the responsibility to satisfy them has been transferred from individuals to communities, to states and to international cooperation. The number of problems which due to their intrinsic nature are world-wide (cannot be solved at a lower level) is increasing.

From all these cases we grasp that there is a common trends for the interactive forces to increase their range. The changed panorama of the "field of forces" (of different ranges) requires to reconsider how we have accommodated up to now to react to such forces.

Approaching a phase of structural change

Human systems are expected to emerge from the 'globality' transition rearranged in sub-systems having different dimensions (range of interaction) and the capacity to manage internally as much as possible of their problems. It is therefore important to try to identify the *new global sub-systems*, if any.

First of all we should ask: *what dimension has the EC subsystem?* Is it a global subsystem? *What problems are "internal" for the EC to be concerned with*?

Of course a subsystem of a given 'dimension', say regional or local, has also to face problems that come from the interaction with other sub-systems (its environment) of different dimensions. There might be a lot of sub-systems new problems which remain local or regional in nature although they originates from the subsystem environment which include *globality* (e.g., the problems emerging from the immigration pressure on Europe).

The increasing gap between the problems that emerge and the ability to deal with them, underlines that we are still in a phase of system transition. The incomplete system restructuring, has induced a separation between the sub-system where the problem emerges from that where there is the ability to solve it.

Institutional changes

Globalization compels decision-makers to consider longer term scenarios when defining policies, choosing strategies and planning actions. It is even more difficult if the resources to allocate to long term issues have to be managed through international institutions and actors.

In fact, increasingly, a variety of issues cannot be addressed, not to say solved, on a national basis. Global policy is the outcome of a variety of actors. Even if state governments are the primary players, other actors, such as international - governmental or non-governmental - organizations (IGOs and INGOs), and even corporate actors such as multinational corporations (MNCs), may exercise a central role.

One should not forget that S&T itself is an actor that has its own institutions and organization procedures. Moreover, S&T is heavily influenced by the increasing

global interdependence, which might produce 'institutional' changes in the S&T organization.

Institutions and Fora have developed in parallel with the different phases of the geo-political globalization as an attempt to provide global governance. We can distinguish three level:

- *International Institutions* created mainly after the Second World War under the impulse of U.S.A. They are distributed on two sub-levels:
  - *Political Global Institutions*: the UN and their families,
  - *Financial Global and Regional Institutions*: the International Monetary Fund, the World Bank Group and regional replicas.
- *Northern informal as well "exclusive" membership clubs* that grew up in the Seventies and Eighties and of which the OCDE is the oldest.
- *new International Institutions* due to the *re-shaping strategies of Third World Countries,* such as UNCTAD (UN Conference on Trade and Development), created to offer a counterweight to GATT.

The present phase of globalisation and of growing internationalization and integration among economies, is greatly marked by a *deficit of governance capabilities at the international and global level*:

- international policy-making, embodied in International Organizations, is affected by a ***deficit in multilateralism*** (see the disarray GATT) and a ***loss of leadership***
- the increased focus on *competitiveness as a prominent policy issue* is provoking a deep concern in *innovation policies*. However, S&T policies are sometimes suffering for a narrow focus;
- the current trend to bilateral and regional arrangements is likely to have an huge impact on multilateral rules and institutions if strong political initiatives are lacking.

1.2 The Economic Patterns Of Globalization [1]

Our perception of the globalization issues and the way we react to them, will depend from our ***vision of the world.*** It is not without effect on our capability to organize responses to the globalization issues whether the world will become a completely open market or if a new mercantilism will prevail (may be within regions having a continental dimension), whether the phenomenon of transnational corporations will extend or not, whether or not the global network of financial sectors, of telecommunications and of other sectors can be seen to behave as "independent" global sub-systems.

The impressive scale of globalization problems emphasizes the availability of resources. Globalization, due to inter-dependence, puts on a unique 'global' discussion table the problem of resource allocation. This makes even more difficult to solve the antinomy between the need of cooperation (to increase resources or better manage the use of existing ones) and the need to satisfy individual actor's perception of priority of needs. The contrast assumes dramatic dimension in the North-South relationship.

[1] This section is a condensed version of the contribution of G.Perosino to the report CSS/fast-10.

By tracing the emergence of new patterns of globalization at geo-political level, it becomes clear the need to develop mechanisms through which a more equitable access to world resources may occur. However, the ways and means to reach these goals are far from clear. Many questions remain open.

Historical trends in international development

Looking backward to our common experience it seems that one of the long-lasting struggle of modern society has been the competition between two, somehow conflicting, priorities: *economic efficiency* and *equity*.
One can say that ***efficiency*** is the core value of ***liberals,*** who consider the market as the best instrument for resources allocation. ***Equity*** is the underlying value of ***socialists,*** who state that the market fails to assure an acceptable distribution of wealth.
The conflict between efficiency and equity has been transposed at international level, particularly in a North-South perspective.

Besides efficiency and equity, there are other values pertinent to the economic analysis of the international system. In a system of national-states such as the one in which we are living, the *national interest* is still a fundamental value. The release of national sovereignty to sovranational institutions has been very limited so far, even in the economic realm.

National-regional interests, economic efficiency and distributive equality are going to remain priorities also in the future as they are "natural" values. Accordingly, the future system will contain elements of each model: liberal, socialist, and mercantilist. The relevant question is what will the relative importance of each priority be.

The great debate: the North - South interactions

The poor economic and social conditions of many countries is a terrible challenge for the incoming generations. Are there perspectives to develop a 'vision of the world' that may help to set the pre-conditions for approaching such challenge?

The past evidence related to the development of *virtuous circle of wealth generation* in LDCs indicate that there is not a definitely better trajectory. It is not easy to find a substitute for the chain of relationships that worked in the North trajectory of development (from basic industrialization, to increased education and social services, to improved industrialization, to extended social solidarity and services, to further economic advances).

Development is a circular process as complementary factors are needed at proper time: capital, foreign currency, infrastructures, education, markets, technology, institutions, etc. (besides social and political conditions). As a consequence, an *integrated, or eclectic, approach to development* is necessary. In turn, this requires a rather high degree of co-ordination among the actors of the development process, not last, among donors countries and institutions.

Is it possible to venture a positive perspective for LDCs, an accelerated path to contextual change? Globalization seems working in that direction, and S&T has its role to play pushed by the development of globalization. *S&T may contribute to LDCs development* in both a direct and indirect way. To the extent that *it promotes worldwide economic growth,* it has a positive impact in terms of exports opportuni-

ties. LDCs may also be affected by S&T innovation as buyers. They would benefit from the development in DCs or somewhere else of *cheap, flexible, reliable, low-import content technology.* Furthermore, they would benefit from co-operation in terms of technological education, technological policy design and implementation, local R&D. Aid could also finance R&D in OECD or elsewhere aimed to meet specific needs of LDCs.

Finally, technology may contribute to *the reduction of the transaction costs of the market* (i.e. through telecommunication, data bank) and, therefore, to the reduction of the costs perceived by TNCs to develop process and products fitting LDCs needs and make new productive investments in LDCs

Towards a 'regional mercantilistic' scenario

Can we dear to trace an emergent scenario that be the results, but also the preconditions, of globalization? It is important, to look for the determinant of changes that characterize the globalization process.

The following global forces seem to be of utmost importance:

i) Demographic changes: they are bound to worsen the already existing *long-term unemployment* problem and its financial and social repercussions.

ii) Environment degradation: it constrains the sustainability of world development as well as current and future quality of life. This problem has global, regional, as well as local dimensions.

iii) Militarization and nuclear proliferation: they increase the risk of regional wars, especially in LDCs, with possible global escalations.

iv) Unique positive political changes taking place in the ex-*socialist block.* World-wide, the *call for democracy* has strengthened in the last decade.

v) Economic liberalization: along with S&T development have been the most powerful factors in promoting the trans-nationalization (in terms of both trade and production) of economic activity during the last decades.

vi) ***S&T development***: it has fulfilled the formidable task of *reducing the productivity of factors and increasing goods and knowledge mobility.* It has enhanced data processing and problem solving capacity. Innovations, such as TLCs, have largely benefited TNCs, as they have been "enabled" to take advantage of the new attitude of host countries.

The liberalization of markets, especially within the EC, has been functional to the exploitation of R&D potential. For a number of products, especially components, such scale that was already beyond national dimension, has become global. As most S&T activity is carried out within TNCs, S&T related investments follow the logic of profit. Consequently, their pattern follows the structure of purchasing power at local, regional and global level.

We can synthesize the role of S&T as a force of change in the geo-political scenario, by recognizing that: while technology has definitely increased economic efficiency, *the equity question has largely remained unanswered at global level.*

From the point of view of international trade, the geo-political scenario seems to lay between a *liberal* and a *regional mercantilistic* one.

During the last decade, TNCs have gained a large deal of influence compared to states and they are expected to further push for a liberal world vision.

Nevertheless, at the same time there are forces leading along the direction of the mercantilistic model. In the EC, protectionism is preferred by those countries, and within each country, by those sectors which are the weak partners of the trade system.

How to fit LDCs in the scenario remain a very uncertain aspect. One possibility is the development of *regional clusters each including its share of LDCs.*

1.3 Globalization patterns in S&T

Since technological development and international technological transfer is expected to play an important role in solving the enormous economic, social and environmental problems, we should expect a contribution on governance from S&T itself. However, scientific development and technological change far from weakening, are increasing *competition and conflict* and amplifying *the divide between rich and poor nations* in the international arena.

S&T is intrinsically neutral with respect to the differential gap in problem-solving in the North and South. Indeed S&T is simply a tool for problem solving. The feeling of the contrary comes from the role that S&T has in helping "to define the problems" to be addressed, by indicating a portfolio of potential solutions (i.e. technology-push contribution to problem identification and solving). On the top of this, one should add that the portfolio of ideas is built up through the progress of undergoing S&T activities.

Since S&T is an 'actor' itself, does globalization affect the organization of the S&T community through the increase of local/ national S&T communities interdependence, through international S&T projects, and setting up networks to exchange data, ideas, scientists? How will this influence the capacity of S&T to improve the global decision-making process? Can, e.g., S&T facilitate to reach a consensus by reducing the uncertainties on future S&T potentialities *vis à vis* the debated issue?

The globalization of science

There seems to be a trajectory towards globalization of industrial R&D that passes through different phases; from **internationalization** (cooperation between companies), to **multi-nationalization** (foreign R&D departments of enterprises), to **globalization** (global strategy of enterprises).

Can one imagine a ***similar trend for public research?*** The phase of *internationalization* is the only one visible so far. Is it foreseeable that a public body - such as a National Research Council - sets up foreign laboratories *(multi- nationalization* phase)? Does *"globalization"* imply to deal with global R&D topics (like marine resource or ozone or climatology studies) in a specific country? How many are the cases of national R&D projects having a global scope/objective?

May we cope with globalization without building an S&T sovranational organization? Let's take the **case of EC**: could it be considered as an example of a regionalization (globalization within the EC region) trend? Can the EC R&D policy be considered as a kind of "global switching" (i.e. regional problem dealt only at regional level to assure efficiency) decided by EC members? .

It will be important to take advantage of intrinsic thrust to globalization of science. One such trend is that of ***science networks.*** Networking, that is clustering of world scientists around research themes is an old phenomenon. The clustering process is somehow *spontaneous* around an informal leader or a 'school'. The process however is not completely spontaneous since it is *indirectly affected by public policies* promoting contacts, providing grants for stages in foreign universities.

'Spontaneous' or promoted, but still bottom-up, *networking mechanisms* are not limited to basic science. The more public money are injected in the *science network mechanisms*, the greater is the temptation to *top-down 'plan' by attracting scientists attention on objectives of social interest.* The results of explicit efforts of top-down planning for basic or applied research are not exciting. Should one conclude that a "lamarckian" top-down approach is not possible and that the only possibility *to change the research agenda priority is to change the context* (selection) waiting for 'natural' mechanisms of adaptation to develop? Is there a way to accelerate such "natural" mechanisms?

To this effect, it is important to better understand the *motivations of scientists and the mechanism influencing them.*

Science leaders, perform a very practical role with respect to the other less genial scientists by breaking down science big issues into smaller problems. To try *to orient scientists' research agenda* it is therefore necessary to provide the same type of assurance. A *strong scientific leadership is required* to guarantee the success of any planned research network.

Can *the leadership* on selected research topics *be organized*? The related policies might be:

- to call leader scientists to redefine research agenda,
- to help the enlargement of existing research networks to scientists living in LDCs,
- to call the scientists to generate a portfolio of research ideas relevant for globality issues.

The globalization of technology

The term 'globalization of technology' has not a unique meaning. It characterizes different phenomena, such as:

- the emergence of "global products" responding to world standards,
- the world-wide diffusion of manufacturing process and production organization,
- the development of 'global enterprises such as the Trans National Companies,
- the *volatility*' of technology (increased accessibility),
- the ability to design and manufacture products using '*generic*' technology.

The different aspects of globalization of technology might not necessarily be complementary or compatible reciprocally.

Recent analysis focus prevalently on the phenomenon of TNCs development, underlining:

- the *emergence of "global networks"* of company operations,
- the optimization of the production process by exploiting the local advantages the nodes of the network through *a "global switching"* dynamic,
- the adoption of a flexible strategy which includes *"global focusing"* (concentration of the entire production process in a node of the network).

An ideal "network" strategy is possible if there are no spatial barriers among the nodes of the network. *The technological change "travel" throughout the company network*. This affects company strategy and organization including the decisions concerning where to locate the different production activities and functions. Because of the technological changes, the "focus" of the activity might have to be displaced from one node of the network to another. The ***"network logic"*** therefore changes the enterprise strategy and mode of operation and make the latter more flexible and dynamic. The dynamics of change might negatively affect single nodes in the network (e.g., the decision to de-invest or to shift activities to other nodes).

Public S&T policies and technology networking

The appearance of enterprise networks requires a revision of R&D public policies. In fact, the basic assumption that production factors freely flow along the network, represents a sort of "decoupling" of the network from the territory. Since many public policies, notably, R&D policies, aim to change the local competitive advantages through the creation or the improvement of production factors, such decoupling seems to thwart such policies.

The problem of the interaction of public interests - as represented by public policies - *with those of the networked enterprises* appears, in any case, to be more complex and contradictory with respect to the case of the interaction with "home-based" companies.

If there are actors that represent the public interest at the broader space level of the network (e.g. the EC Commission for enterprises that have developed European networked operations), it seems that such actors should appreciate the technological transfer (TT) characteristics of the network and accept its intrinsic rules of mobility and the long-term effect of space homogenization.

Should instead local public actors perceive the establishment of a network operation logic as a threat? Here the suggested hypothesis is that also local public actors could *consider positively the grow of networks provided that the network logic is consistently applied*: e.g., incentives may be designed to attract to the local node instead of manufacturing activities other production functions, including R&D.

The policies designed to change the context (e.g. aimed to increase research or advanced services) should find more sensible a real networked company than a domestic-centred hierarchically organized one.

Globalization and 'generic' vs 'specific' technology

A more general question for public R&D policies concerning the "global networking" phenomenon is the following: *taken for granted a potential TT effect through the enterprise activity along the network, might appropriate policies be developed to increase the spatial homogenization effect, and to accelerate the transfer of the technological potentialities to the local context so to help creating production factors at the nodes of the network? Could public policies intervention stimulate appropriate changes in the enterprises strategies?*

Of top importance will be the *initiatives that contribute to increase the 'generic" content of technology*. The more enterprises make use of generic technology, the greater are the chances that local entrepreneurs gain access to technological po-

tentialities. This objective seems to be in contradiction with the attitude of any enterprise - including the networked one - to keep the technology as much specific as possible, that is with a high degree of appropriability. However, the contrast might be more apparent than real after one has better cleared the concept of generic technology. A product or a production process can be seen as a complex system made of sub-systems, components and materials. "Appropriability" might concern all level: the entire system, the subsystems, the components or materials. An enterprise might therefore have interest to increase the "genericity of use" of the subsystems and components that enter into their products by making them available to other entrepreneurs to produce different products.

Appropriate public policies could therefore push enterprises to look for new products that might be developed by "assembling", with "generic" technologies, high appropriable components, and/or to cooperate with other entrepreneurs by making available these components for the realization of new products/processes.

The contradiction between the high appropriability of 'global' technology (because of "specific"/"localized" technology, scale of production, thresholds barriers to enter for new comers) and "local technology" tends to disappear by shifting the concept of 'globality' from the product/process systems to their components.

2. THE GEO-POLITICAL CHALLENGES: GLOBALIZATION AND GOVERNANCE [2]

Globalization is the set of processes which result in the increased interrelatedness and economic inter-dependence of previously fairly separate national economies; and the conditions in which a fraction of value and wealth are produced and distributed worldwide, within a system of interlinking private networks. Globalization is a dynamic process which is continuously evolving.

Looking to the quantitative aspects of globalization a first question relates *to what extent globalization is global.* In fact, globalization is a phenomenon until now limited to OECD countries and to a handful of developing countries.

Technology has acted, as an enabling factor, a pressure towards further globalization, for example as a result of the convergence of computer, communication and control technology.

The present state of globalization process looks more as a chaotic global picture of weather forecasting than as a clear and geometric network of linkages and knots. *How is a global society able to formulate social and political categories such as cultural and ethical identity, shared values and societal integration, where it lacks of authority centers and core structures?*

During the past decades there was an *underlying creed among analysts* that to respond to interdependence and complexity one should look for ways to exert control, to rationalize and manage the complexity and to standardize responses. *The process of globalization* was substantially perceived *as something to be reduced to simpler units of analysis and to smaller sub-units of operational intervention*.

Following suggestions coming from the natural epistemology, social scientists and economists, however, *begun to give more room to cognitive rationality*. Concepts such as learning, cognitive mapping, cognition were asked to help for non-conventional analysis in organizational, technological and institutional issues.

However, neither the rational choice, nor the learning approach taken alone can offer definitive solutions. As actors in an interdependent and ever-changing world need to collaborate in order to manage problems of increasing complexity and magnitude, they need to resort to strategies enabling to reduce, even if not all at least some aspects of uncertainty.

By adopting an intelligent information processing, national governments and sovra-national and global institutions can detect obstructions and obstacles in view to assess a network of actors to remove them. What results is ***governance***: a mix of institutions at different territorial (sub-regional, national, sovra-national and global) and functional (financial, informational, organizational, juridical, etc.) levels whose activity is loomed with the selection of topics and the creation of institutions to manage problems.

To pass from government to governance is a shift in the way to conceive *the governmental institutions as a "learning" support for actions and not only as an instrument of the national state interest*. Governance and not only government, co-

[2] This chapter is a condensed version of the contribution of M.Campanella to the report CSS/fast-10.

operation and not zero-sum games are the new topics of the post-cold war global order.

2.1 Globalization: a three stages phenomenon and its perspective

In respect to the evolution of globalization in the last four decades, there is a wide agreement in the literature on distinguishing two different phases, the ***hegemonic stability*** (1945-1969) and the ***post-hegemonic instability*** (1971-1989). Of a third stage of globalization, there are growing evidences in the difficult negotiations of the Uruguay Round, and in the regionalization of free-trade and cooperation blue-prints. We suggest to label this emerging third phase as ***Multipolar Regionalism***.

The *post-hegemonic instability*, starting with the 1971-1973 oil shocks, is characterized by increasing uncertainties in many fields of world affairs. A main front-line was a generalized attack of Third World countries, including OPEC countries, on international regimes regulations and rules and a reaction against the process of globalization ruled by Multinational Corporations (MNCs).

By the end of 80s, something has begun to change very quickly. Developing countries had become more *dependent than ever on trade* and their stake in the maintenance of a liberal international trading regime had risen proportionally. Slowly but surely, a number of developing countries begun to realize the necessity to join GATT as their only chance of imposing discipline on U.S. trade policy and ensuring continued access to U.S. markets.

As globalization has meant successes and failures for all partners participating in, but only failures for those who have deserted it, some lessons could be learned:

- **for developing countries** the lesson is that *the fight against liberalism has exhausted its fighters*. Openness to international environment and capability to remove domestic obstacles to them are the two most important topics of a successful management of globalization;
- **for Northern countries** there are also several *lessons* to be learned. *First*: there is not such an evidence that globalization requires homogeneous and highly industrialized economies to integrate. *Second*: being MNCs (and the environment of private actors) key-actors of the process, a great attention has to be addressed to their strategies in Technology Transfer. *Third*: Public bodies and public policies cannot be regarded as second-choice actors. *Fourth*: Corporations and other non-state actors - part of the multi-centric world, centerless and decentralized - are the main source of dynamism, volatility, uncertainty and turbulence.

2.2 North-South Relations. Old and New Perspectives.

Theories in use among policymakers and analysts in the decades after the building phase of International Institutions were mainly ***basic human needs***, ***liberal reformism***, and ***interdependence theory***.

The *emphasis on basic needs* exemplifies a wider trend: some Western elites are advocates of the "politics of sensibility". These elites have come to assume that the Third World is primarily concerned with improving the well-being of individuals.

General economic performance in the South has been a second focus of attention for Northern policymakers and analysts. One has to underline the *debate between orthodox and reformist liberals.* Orthodox liberals have emphasized domestic factors in the Third World, while reformist liberal have also taken global systemic factors into account. Reformist liberals are more tolerant of domestic policies in developing countries which do not strictly accord with market principles. They accept the infant-industry argument. In general, ***liberal orientation*** have dominated American attitudes toward the Third World countries.

The focus in ***interdependence theory*** shifts from the well-being of the Third World (satisfaction of basic needs and liberal perspectives) to the links between North and the South. Partisans of the interdependence perspective maintain that this is a world that cannot be adequately understood by focusing on states and power. Economic failures for the South would have dire consequences for the North.

Only *in mid 80s something new ways begun to be introduced about North-South relations.* According to *Krasner's* ***Structural Conflict*** theory, North-South conflicts are rooted in profound asymmetries of power, and political weakness and vulnerability are fundamental sources of Third World behavior. *Vulnerability, and not simply poverty, is the motivating force for the Third World 's meta-power program for transforming international regimes.*

By adopting Krasner's perspective, governance institutions and obstacles to manage globalization are more apparent, and can be better addressed.

States and public bodies are considered as relevant actors, and not, as in the first version of the interdependence theory, as weak and declining ones.

2.3 North - North Tensions

In the late Eighties and early Nineties, a growing trade conflict among US, Japan and EC is eroding the paradigm of collective management of world economy. *The hope that the Triad power could be governed through collective management is today seriously challenged with the crisis of some key-international organizations such as GATT.* Even if free-trade continues to be the official creed of Triad governments, a new mood for protection against hostile and unfair competitors is growing among highly industrialized countries.

Protectionism vs. free-trade doctrine is perhaps the major global issue in agenda. Even in a regional context - such as the EC - economic nationalism remains a potent force and a major barrier to the free transfer. This produce unwanted outcomes such as market fragmentation, low rate of high-tech activities, etc., which are only few among others.

Concerning S&T, a base antinomy is emerging from globalization. On one side, globalization means the world-wide spreading of the S&T advances which should in principle be an endowment to all human kind. On the other side, one sees increasing attempts to make individual use of such endowment to compete and fights one against the others. S&T policies therefore oscillates between the push to increase the 'generic' value of S&T and helping the local appropriation of its potentialities.

The increasing possibility to 'appropriate' technology provided the needed investments are made, raises unfair games to profit from volatility of high-technologies.

Trading blocs (such as Mexico-U.S.-Canada Free Trade Area) is a strategy that is substituting classical adjustment policies, making possible a domestic economy to react (and to adjust), in a more sustainable and self-reliant way than previous state-policies limited to domestic environment.

As globalization and high-technologies marketplace represent in a very dramatic way the new role S&T have conquered in the political agenda, which consequences will arise for the Technology Transfer and more in general for the global cooperation? How will technology be transferred to poorer countries if the harshness of competition and threat of retaliation will endure among Triad countries?

A dominant opinion sustains that TT has played an actor's role mainly due to the effects of the "hegemonic stability", with US acting as a stabilizer. Conflicts among Triad countries are generating a great lack of policies capabilities. Further, contradictory aims and goals affect very easily the restricted margins in which policymaking does operate.

2.4 Governance and Proactive Policymaking

Political and institutional conflicts between North-North, North-South and East-West had impinged on the technology transfer and in turn on the full availability of technological and scientific innovations. Ideological and institutional tensions are the true obstacles to technology transfer.

Several international organizations - particularly the UN family - have ceased to perform in effective policymaking, limiting themselves to denounce more than to propose concrete policies and institutional behaviors.

A second limiting factor that a policy analysis cannot ignore, consists in domestic obstacles, such as the (national and sub-national) formal-legal constitutions of each country. Obstacles arise also from private sectors (corporate organizations), financial market, university system, and their interactions at domestic scale.

As great need of policy improvement is interesting all spheres of governance, analysts and practitioners are confronted with the search for betterment of policymaking at global governance level and for a refinement of policy analysis. Innovation in policy analysis and policymaking formats is needed to supply decisionmaking with improved and bettered approaches, including an increase of portfolio of ideas. What we need is a new understanding of the coordination and cooperation among actors.

Standard, Non-Standard Policies

Standard policy analysis anchor the decisional process on a decision-maker more or less committed to decision and its consequences, but substantially being an atomistic actor facing an environment of other actors. Standard policy analysis starting point are motivation and expectation. Agent's competence, ability and capability are: a) to assess and to select alternative choices; b) to lead institutional game at domestic and international level; c) decision and implementation; d) performance measurement.

Policy science is trained to face national domestic problem-solution, and to adjust domestic environment to international challenges. The policy making process is a cycle composed of several phases: intelligence, promotion, prescription, invoca-

tion, application, termination, and appraisal. Promotion, prescription and invocation are the main phases of the political cycle of policymaking.

These activities are hardly performed when decision-makers act under non-optimal conditions.

The actors' cognitive capabilities limits to manage policymaking process are due to very limited resources in span attention, information processing, and alternative assessment. Three different uncertainties affect policymaking:

- *uncertainty* pertaining to the operating *environment*;
- *uncertainty* relating to policy *values* and ranking;
- *uncertainty* relating to the intentions in *related fields* of choice outside the current decision agenda

More appropriate ***non-standard policy analysis*** should be developed to cope to authority lessening and to the other several factors pertaining to actor's diminishing capabilities.

Revisiting Policymaking

Technology Transfer policies need a more adequate approach to cope with uncertainties, turbulence and fast changing scenarios. Crucial demands range from how to compensate for cognitive limits of actor-decision maker, to how circumvent unavoidable inflexibility of local-national administrative structures and cultural patterns.

A trap to avoid is to use standard policymaking paradigms and procedures for problems wrongly supposed belonging to the same class.

Policymaking knowledge is one step further removed from discrete policy issues. It deals with the policymaking system, with how it operates and how it can be improved. Available policymaking knowledge deals, for instance, with: *how organizational structures operate; ways to improve the quality of the people engaged in policymaking; methodologies to package and use information; patterns of intersectorial coordination and integration of different policy-units; design of decisional process and betterment; evaluation and organizational learning.*

Key-questions are:

- Over-unified unity of command and central planning has shown deleterious incapacity to cope with complex and interdependent systems. Which kinds of new "long-term" policy we need to design in order to cope with non-linear phenomena (technological and environmental risk, poverty vicious circle, etc.)?
- Is it really long-term policymaking the best response to problems of competitive challenges, or we need a more sophisticated response in which are included the notions of recursivity, organizational learning, and institutional reliability?
- May we design an effective new paradigm of coordination and cooperation avoiding "idealistic failures"?

Even if better policymaking is not a remedy for all problems of governance, but only one dimension of required redesign, it is one key-instrument at hand for approaching our preferred state of the world.

European Lead and the Policy Agenda

One should consider that we are facing in reality a problem of interaction between *problem and problem-solving approach.* We should at the same time approach the two side of the coin. This has to be kept in mind to address in general the question of which role EC could play in policy making with respect to globalization.

The Single European Market has arisen many fears about "Fortress Europe" or protectionist closure against its main competitors the U.S.A. and Japan. Anxiety is also growing among developing countries from the uncertainties of European Commission in crucial matters.

Another concern refers to the contribution of the EC to assure a *sustainability* scenario. Sustainability is the equilibrium point between technological development, citizenship, and rights of the nature to be preserved for itself.

How will the New Europe be able to assume sustainability as an axial principle? Is the European Lead ready to cope with the challenges of non-equilibrium growth?

The notion of ***Europe as a Civilian Power*** perhaps could help to come to a better understanding.

Foci of a ***functional-global agenda*** to play such a role, are the following:

- protectionism and free trade, in particular the EC policies in GATT negotiations;
- Community and Eastern European Countries relationship;.
- Community-Third World relations, in particular African countries (FTA Model?) .
- setting up a new '*international competition authority*' to establish standards and regulations (food and drugs, electrical goods, ICT).

3. LEARNING TO MANAGE GLOBALIZATION ISSUES [3]

In the international agenda an increased attention has been devoted to S&T, in parallel to the economic and trade subject matters. Indeed, following their more traditional tasks - exemplified in the technological innovations for economic growth and welfare - the support expected from science and technology gradually expanded in a variety of policy relevant economic and social issues such as food, health, transportations, communications, energy and industrial innovations.

The basic issues in trying to develop the potentiality of S&T in an international political environment is that the international institutions and the related decision-making process developed before the perception of globalization. Will such organization be able to deal with the globalization related problems, including the use of 'globalized' S&T?

3.1 Science and Technology in the global policy process

Increasingly a variety of issues cannot be addressed, not to say solved, on a national basis. They deserve international consultations, ample international agreements, effective control and management activities and massive allocation of resources. In other words: an ever growing variety of policy problems deserve to be faced through international coordination.

Defining S&T related global problems.

In general, international policies can be defined as joint efforts to cope with problems that are shared by more than one state. With the term of *global policies* we refer to a subset of *international policies*. Global policies deals with problems that are global in their scope, such as:

- trans-boundary problems,
- international commons,
- internal problems, if internationally shared.

Scientific knowledge and specific technologies play a crucial role in approaching and/or solving those problems. Yet some questions have to be asked at this point:

- What changes the extended use of science in new areas of socially and politically sensitive problems, brings about in the policy process; and to which ways it modifies the basis upon which decisions are made?
- Are changes in socio-organizational structure of science required in order to adjust scientific research and its technological outcomes to its second order effects?

Science policy: a received view.

The links between science and policy are currently epitomized with a couple of locutions. ***Policy for science*** indicates that governments increasingly relies on scientific and technological knowledge and need to promote the health and growth of S&T as a policy resource and as a source of benefits for society.

Science for policy suggests that science affect the policy process through: i) its prod-

[3] This chapter is a condensed version of the contribution of V.Ancarani to the report CSS/fast-10.

ucts by expanding policy makers options and issues, ii) its evidences by generating a more informed analysis-based policy making, iii) its methods by bettering the traditional policy and administrative habits offering analytical techniques in evaluating decisions, programs and procedures.

Yet, the alleged reciprocal independence and instrumental exteriority of relations between the two realms should be considered more as a special case than as a general feature.

Science for policy: a revised view.

This traditional view needs to be widely transformed and reconsidered, and a new conception of science for policy must be worked out.

Sociologists, epistemologysts and students of science policy, are facing today a major theoretical step to include S&T "externalities" and "uncertainties" into their theoretical framework.

Epistemologysts has begun to consider science more as a largely conjectural exercise than as truth-reaching activity. The sociologists of science have emphasized the provisionality of consensus and the intrinsically negotiated and socially constructed feature of scientific "facts" and theories.

The use made of scientific knowledge by the research scientists, inevitably affect their standard of truth. The flow of knowledge through different application area is inevitably exposed to different considerations of priority, relevance and validity which are related to the new users.

The process of knowledge transfer and use in the policy practice, can hardly be regarded as a linear model. Much of science productivity and coherence do not stand in hard facts, but "is a result of the social achievement of consensus and of temporary setting aside of many inconsistencies and anomalies".

A corollary of this revised view is that, when exposed to a different environment and intended use - as it happens with the policy process - scientific results and informations must fit a new context of expectations, evaluation criteria and procedures.

The certainty bias.

An exemplar case to be considered when analyzing the knowledge transfer to a policy arena of utilization, is the "certainty bias" occurring among the two different institutional contexts.

Suppose policy-makers need urgent decisions on a specific issue which, at that moment, does not possess the appropriate knowledge base. In all these cases science loses its interpretative control over uncertainty on a scientific/technological matter that is turning critical for a policy issue.

If science can be used at a level of uncertainty unacceptable by its standards, the reverse can also be true. A strong knowledge base can be refused as undesirable by policy standards too.

We can distinguish between a scientific-technical and a socio-political uncertainty, on the basis of different standards and ways of achieving social consensus on what is reliable and usable information.

Under these conditions science for policy is growing as a new branching of science which yet deserve careful scrutiny and improved design.
Scientific and technological information and solutions must be fitted in a policy decision process involving social, political, and economic interests as well, in which problems tend to be defined in arenas of contending groups.

The global policy-making process and arenas

The process leading to international cooperative behavior is constrained by a variety of indigenous and exogenous factors and can occur through relatively stable parameters or more dynamic and even volatile events.

The ability of science to initiate (not to say to influence) a policy process is difficult to state. As a dynamic process, the international policy-making is the product of a variety of actors and crafted in a organizational context. The actors concerned with a policy problem demarcate a *policy arena*. If the policy problem incorporate highly scientific and technical knowledge, groups or communities of professional experts had to be put together to inject up-to-date knowledge resources and advice. Moreover, the beliefs systems of the decision makers can evolve as consequence of fluctuations in the dominant ideologies or in the relevant knowledge base of the problem to be solved.

Even more complex is the process of problem formulation and setting. Goals can be defined as "specific" or "interconnected", "static" or "expanding". The actor can seek the attainment of a single outcome (e.g., a higher per capita income or cleaner air) or an interconnected goal.

The way the relevant actors define their explicit or implicit view on a specific issue, the objectives to be pursued and the policy strategies to further their policy objectives are often quite different. In fact a problem can be variously perceived and framed.

In the case of an international/ global policy process, states constitute the major actors but also international governmental and non-governmental organizations are often important, and even corporate actors.

3.2 International institutions and global problem solving.

As the Cold War relaxed, there was a growing awareness, even among the wide public, concerning the various problems of increasing interdependence and the magnitude and number of the global challenges which cannot be adequately addressed without international cooperation.

Among the topics, which quickly moved up the hierarchy of the new global agenda, the environment and resource management issues looms the outstanding.

The emerging of a wider public concern.

Many separate events were responsible for this growing concern for environment and resources. As far as the resource issue is concerned, the oil shock of 1973- 74 was a major one. It made clear the threat to the stability of the international economic order originating from the shortage of a basic commodities. Concern on environment developed after the numerous accidents responsible for massive oil spills and with severe consequences for marine life and fishing. Major accidents,

such as those at Bhopal and at Chernobyl, were partly responsible for the new burst of the international concern for the global environment in the second half of the ’80s.

All these problems have localized, easily perceived and even dramatic environmental consequences, so they captured wide public attention. At the same time they fostered a growing concern about trends which are evolving slowly, are less tangible, from which more concrete effects are expected in the future, but with consequences which may be even more severe and even irreversible.

More recently two of the above outlined environmental problems joined the headlines of newspapers virtually everywhere, pressing governments and the international policy-making machine to take urgent action: CO2 emissions and the depletion of the ozone layer of the stratosphere.

Global Policies and the International Institutions.

Even if the involvement of the generality of states is not a necessary requirement, the global decision making process must be universally open to the participation of all of them. As a consequence global policy problems are taken up in the United Nations (UN) framework.

Resources and environmental matters offer a variety of examples of the need to address global problems collectively. Without doubt in such issue areas, governments are confronted with problems that are virtually eroding the principle of the national sovereign state in world politics. The other side of the coin is that such issues also epitomize how international institutions and policy-making face obstacles (often insurmountable obstacles) in building new viable and effective arrangements concerning S&T related global issues.

As far as the policy responses are concerned, the UN, and especially its General Assembly, through the very active role of UNEP (UN Environment Protection agency), are performing an impressive undertaking in promoting international law and regulation of the environment.

3.3 The ozone case

The efforts to negotiate an international regime protecting stratospheric ozone can be considered as a success story in environmental matters having a global impact.

The ozone case can be viewed as a long-term international process involving different phases. The early scientific understanding of a potential threat to the ozone layers, stemming from CFCs’(chlorine-fluoro-carbon compounds) released chlorine in the stratosphere, date back to 1974.

Because of the global nature of the issue, the involvement of a multilateral organization like UNEP, was a major step in making ozone depletion an international policy problem.

In 1977 UNEP begins to promote monitoring, data gathering and research efforts. In the same year it set up a scientific panel, the Coordination Committee on the Ozone Layers (CCOL). In the years to follow, CCOL was also able to play an outstanding role when the true negotiation phase begun. As a technical body displaying a composite membership, melting unquestioned scientific expertise with various organizational appointment and association in interest groups, CCOL served as an

important forum where scientific and political conflicts can be simultaneously negotiated.

It was only in 1981 that UNEP's 58 nations Governing Council finally authorized the agency to begin negotiations aimed at reaching an international agreement on protecting the ozone layers.

In march 1985 in Vienna the Framework Convention was signed by the representatives of 20 states, including all major producers of CFCs, and of EC.
The Convention explicitly recalled the broad set of principles previously set up in the Stockholm Declaration. Particularly: 1) the recognition of States' responsibility that activities within their jurisdiction do not cause damage to the environment of others States; 2) the acknowledgment of the ozone depletion as caused by human activity; 3) the need to protect human health and the environment against adverse effects resulting from modification of the ozone layer; 4) the need for international cooperation in research, monitoring and information exchange; 5) the recognition of the special needs of the developing countries.

Informality and a full cross-section representative of all the interested parties (academics, industrialists, environmentalists as well as UN and governments' officials) proved very conducive in the building of a growing scientific consensus and more common understanding of control strategies and equity in burden-sharing.

In March 1989, at another major environmental conference held in London, the EC environmental Commissioner, proposed to ban all production and use of CFCs by the end of the century. Two months later in Helsinki, bringing together 80 nations, most of them from developing countries, a Declaration was adopted which supported a total ban of CFCs by the end of the century, the development of substitute technologies, and plans to help developing countries financially and provide them access to replacement technologies.

In June 1990 at the London meeting the original Protocol was revised. The most important new provisions establish:
- the creation of a multilateral fund ($240 million for the first three years)
- the industrialized countries commitment to provide environmental safe substitutes.

The Protocol, set up an important precedent and definitively confirmed that it is possible to make progress toward a multilateral strategy on environmental issues even when nation states' interests can collide with global needs. It also made clear that international coordinating policies need to devise a framework of incentives to gain wide acceptance and an equitable way of sharing costs and benefits across nations, especially the developing countries. It also stressed the need for adaptability and long- term flexibility to accommodate knowledge changes.

3.4 The ozone lesson.

The evolution of ozone policy give us some fruitful insights:
firstly: the ozone case is telling of an enduring international policy-making process in which changes in S&T knowledge widely paralleled, interacted and affected the policy process;
secondly: it is also a pioneering case, able to establish a precedent and set some valid guidelines in coping with international environmental management.

The Montreal Protocol set up a new model of flexible agreement for coping with long term environmental risks. It also showed very effective in resisting a huge change in the number and composition of the actors concerned with the ozone problem. Some of the key points of the lesson gained are here discussed.

Early scientific warnings. To take action before any tangible critical event is hard to be pursued by political standards. In the case of ozone depletion no identifiable episode of crisis (unlike nuclear accidents or marine oil pollution problems) was politically available to foster a large number of states to focus ozone as a problem requiring measures for a solution. The process of pushing governments to seriously mind the ozone problem begun with the alert of the scientific community.

In the ozone case scientists gave an early warning to policy-makers. The lack of certainty on the ozone layer depletion was complemented by the capability of the scientific community to convey a sense of shared *urgency.*

The role of International Organizations. It is difficult to state clearly how relevant, and under what conditions, International Organizations can be in enabling more international cooperative behavior among states. UNEP played more than an active mediating and catalytic role in the ozone multilateral diplomacy.

Some commentator goes so far as to see an entrepreneurial role for UNEP. In this context entrepreneurial capability means a practice involving "imagination in inventing institutional options and skill in brokering the interest of numerous actors to line up support for such options".

Integrating science in international policy-making. The organizational context. A more demanding question is to ask how scientific knowledge can be integrated into the policy-making process. To focus on this more constructive role, we must look at the organizational and institutional context influencing the impact of science on international environmental policy.

In the ozone case UNEP/CCOL played a major role in incorporating scientific knowledge into the international policy-making machinery:

- as a ***policy-oriented scientific body***, it assured cross-sectorial, transdisciplinary work and an acute perception of the policy issues at stake;
- as an ***aid to policy-makers*** in an area of uncertain technical decisions,
- as a ***forum of interested actors***, it pursued negotiations and consensus building efforts to reach sufficient agreement,
- as a ***relatively unpoliticizated communication forum***, not only it was very effective in informing and soliciting governments and world public opinion on the issue, but also committed in avoiding excessive politization and instrumental use of tactical issue linkages.

UNEP offered a range of relatively depolicized communication forums, able to flank more openly political negotiations, which proved an useful institutional negotiating setting and a very effective tool in fostering and building a policy agreement.

The role of leadership. The driving role of an highly committed international actor, proved also very conducive as a determinant of success in reaching an agreement. US government played this role. As the largest single producer and consumer of CFCs and other gas destroying stratospheric ozone, in 1977 US undertook

a domestic regulatory action (the Clean Air Act amendment) against the suspect substances.

The role of Developing Countries. The role of the developing countries in the phase leading to the 1987 Montreal Protocol, was quite occasional. The industrialized countries largely dominated the bargaining process.
To be viable and extend over time, all the - even potentially - relevant actors must be involved in the agreement. As a consequence, provisions aiming to meet the interest of developing countries were added in the protocol to foster them to accept the treaty obligations. After Montreal, developing countries begun active around these issues, so expanding the range of actors involved in the ozone game.

The role of NGOs. Chemical companies and environmental organizations also participated as pressure groups to the policy-making process and were informally involved as observers in the official negotiations.

Designing a long-term flexible institutional arrangement and agreement. International environmental agreements must face, in the long-run, various uncertainties related either to the impact of changes in the knowledge base and in the policy arena (given the variety of actors involved and volatility of interests in international society).

3.5 Implications for global warming policies.

The CFC problem has been easier to approach than a comprehensive international agreement on greenhouse gases. CFCs, which also are heat-trapping gases, are quite marginal to industrial economies. By contrast CO_2 discharges (responsible for at least 50% of the greenhouse emissions), are widespread, difficult to monitor and - being linked to the energy use of the industrial societies - at the core of economic life. So problems arising in approaching an effective greenhouse policy are made more difficult because of the enormous social and economic implications.

Despite difficulties, the greenhouse concern is gaining momentum, involving scientists, environmental groups and even countries unilaterally deciding to curb emissions of greenhouse gases.

The first requirement to be satisfied to gain a workable climate agreement will be *to link greenhouse policy firmly to the economic problems*, particularly of industrializing countries. Linking reduction of releases and burden-sharing to a wide range of macroeconomic and developmental issues is mandatory if widespread participation of developing countries must be assured. These issues must include: energy efficiency improving investments, technology transfer, forest policy, and so on.

Another issue to be carefully dealt with is one of *institutional and procedural design*: what institutional and procedural arrangements are more likely to give real advantages in terms of effective and durable climate agreement?

A criterion of *long term flexibility* has to be carefully considered in designing a workable framework for such an agreement against rigid *control-command strategies*, such as when a Greenhouse Authority is suggested.

Market mechanisms, such as the proposals for a greenhouse tax or a system of *tradeable pollution permits*, allow national approaches to develop but their results seem mixed.

A comprehensive agreement approach - implying the negotiation of a widely based *Law of the Atmosphere* and incorporating a variety of issues - seems less than promising (and indeed the idea has recently been rejected).

The *convention-protocol system* (as exemplified in the Montreal Protocol) is more favorably regarded. Under this approach a two step process is devised. The first step is a so called framework convention, comprising a series of general statements within which a future protocol (the second step) can be negotiated.

Part II APPROACH TO PROBLEM - SOLVING

4. GLOBALIZATION, COMPLEXITIES AND PROBLEM SOLVING

Dealing with globality issues, it seems quite reasonable to suspect that they pertain to a class of issues/problems that the society, as it is now organized, is not able to approach. Can we, with a world divided into sovereign nations with different political and social organization (*state-centric* world model), approach problems which have reached a real global dimensions simply by agreements and cooperation among independent partners? Even the emergence of a turbulent *multi-centric* world does not assure a better dealing with the globalization issues.

Are we not, in the case of globalization, confronted with problem that - even if we are able to specify them - we might be intrinsically unable to solve, unless we make some basic shift in our *vision of the world,* in our organization? [4]

Concerning the globalization issues, the basic question is whether or not we can (by using better knowledge; by generalizing the ways and approaches we are used to in problem-solving; by being ready to make "structural" changes in our organization) keep the related problems in the same "class" of problems that are within our reach. We are confident that a positive answer can - have to - be given.

4.1 Globality: a higher level of complexity

What impresses us with globality issues are, first of all, their complexity, in the senses of "*everything interlinked with everything*". Can we reduce such feeling of untamed complexity?

First of all we should recognize that we are used to complexity: we face it everyday at every level of our actions. Globality therefore might be seen as a generalization of something we know well: an higher level of complexity.

A complex system can be schematized as an hierarchy of interrelated components, integrated in sub-systems which contribute to the system objectives and, by their interactions, actually represents the system itself. Outside of the system is the environment. The system is structured into different levels of subsystems down to a level where we found only "elementary" components (unbreakable "atomic" bricks).

This simple scheme can be used to build much more complex systems as a "*self-similar*" object: using different "unit ruler" to observe the system, we will perceive always the same basic structure. By using a magnifying lens the "elementary

[4] A metaphor from mathematical problem-solving might help to better focus the general problematique. In the domain of natural numbers (positives and integers), we can define the operation of addition and we know that a solution will always be found. The operation of subtraction can as well be defined. However, to assure to find always a solution we have to make some basic change: to **shift** to a wider realm of numbers (include the negatives ones).

components" become actually complex systems, that are made of lower scale "atomic bricks", having as environment the higher level components of which they are parts. Looking at the earth from a satellite it can be seen as a system where what we on the earth perceive as our environment is actually part of the system.

What is new of globalization is that it has raised the scale of complexity, so that at least a part of what we were used to consider as our environment becomes actually part of the system itself.

4.2 Learning from past experience in problem-solving

If we are used to complexity, then - as active members of the system that we perceive as our own - we are used to act (react or pro-act) to respond to the system challenges. If so, we should hope that to deal with globality challenges we can learn from our experience.

The trick we uses in dealing with complexity is to limit the range of the complexity of what we consider "our" system: we *expel* higher levels out of the system to make them part of exogenous environment (we cannot act to change the environment; we can only try to forecast its changes to take pro-active decisions), and we *accept* as "atomic" unbreakable parts some of the system components and inputs we use (reactively or proactively) to change "our" system.

The limits of reductionism.

We are used (since Descartes) to consider a reductionist approach to problem solving: to break down complex issues into small pieces and from them to build - *bottom-up* - a complex solution.

However, this implies an intrinsic linear chain of cause-effect relationship between the elements of the system where the problem emerges. Since we know that there are non-linear feedbacks in complex system, the reductionist problem-solving approach implicitly assume that the feedbacks could be "frozen", taken for given, be part of the past of the system and not significantly modified by our intervention to change it. This approximation is in many practical cases a satisfactory one (very small actions on a highly inertial complex system).

If globalization brings to the fore interdependence among system members of such a magnitude to challenge the identity itself of each member (changing the system structure), than the *reductionist / separation (decoupling) of variables* problem-solving method is no more satisfactory.

The design approach.

We should therefore look at other procedures, which accept intrinsically the non-linearities. One such procedure is that of the design.

In the design approach - even in the very simple case of an architect that have to provide a solution for a customer wishing a new house - complexity (and feedbacks) enters in a not eliminable way.

In the case of building an house for a family the process start with the customer having a vague idea of what he really want. Before the architect can accept the job, a better and clear definition (problem specifications) of the terms of reference of the problems have to be developed. This is done by a complex process of cli-

ent/architect interactions that take into considerations the existing portfolio of ideas on types of housing, preliminary sketching of alternatives, etc. The process ends when the client initial vague desires are well spelled-out. We can call this initial phase a "*meta-design*" (all the solving steps already intervene even if only in a "simulated" design).

Now the problem passes to the architect's direct responsibility. Before he could develop the real solution, a creative phase has to intervene. And this is a most non-linear process where all the variables are again put together, the specification is challenged items by items, somewhat rejected in the designer mind (the phase is called a "*divergent*" one), up to the point when the designer feels that the process can stop and a "final" solution emerges. While this designing phase is the prime responsibility of the architect, the client will be called in, to get his agreement on details which can change the agreed specifications.

The process is an iterative one also when we pass to the implementation of the detailed design. Most of the interactions in the construction phase are between the constructor and the architect. However, in some instance, the client himself has to intervene to take final decisions.

In the design case we are faced with a "*micro*-world" complexity which however contains all the features of complexity and non-linearities of a "*macro*-world" complexity.

The proposal, here, is to *refer to the design problem-solving process as a paradigm for the highly non-linear case of globalization challenges*.

Organizing for the design approach.

There are two extreme models of human behaviour in approaching complexity (two cultures): the one represented by the human and social scientist and the other by the physical scientist. We can refer to the first approach as "*holistic*" and the second as "*reductionist*". The "design" approach is actually a compromise between the two: it is an interactive chain of "holistic" cognitive approach and "reductionist" building of solutions.

The *design paradigm* suggests that an important preliminary organizational rule has to be followed: *to define clearly the roles of different actors* in order to contrast the fuzziness caused by complexity and interdependence. *The process can be considered as a chain of loops centred around each actor*. Each loop is covered a certain number of times involving the interactions of all the other actors up to a point when good enough convergence is met, so that it can be decided to pass the responsibility to the next actor (from the client, to the designer, to the producer).

One of the major difficulties encountered in dealing with global issues is actually the lack of such clear role subdivision. There is a perceived challenge to be met, therefore there is a demand to do something. But, who materialize such demand in term of playing the role of the "*client*"? S&T can represent a potential supply of ideas and initiatives to develop solutions. But how do we organize the related response?

The difficulty to clearly define actors and roles is however not new. Even in the case of producing goods to satisfy clear needs, the "client" usually is represented by the market which is not a physical person. The producer has to guess what the

"market" (the future potential customer) will appreciate. To do this in practice, the producer has to simulate by himself the role of the client. The problem is much more difficult for the case of a radically new product. In such a case, changes in the firm organization are often needed (such as the project and/or matrix organization). The success cases show the importance of clear definition of roles to simulate *client/ designer/ producer* and the assumption of related responsibility by some one.

Globality issues are similar to the case of radically new products. The existing organization (at all levels, local, regional, world-wide) is not apt to deal with some of the more radical issues of globalization. The design paradigm suggests that a central role to be developed is that of the "client".

We might very well feel the globalization challenges, but unless we will clearly succeed in transforming them into problem specifications it will be difficult to allocate the needed resources, to call the contribution of the S&T community.

Not all the globalization issues pertain to the same class. Some are really world-wide, some are emerging at local level through global interdependence. The "game" of decision-making and problem-solving has to be played at a scale which is proper to that of the single issues we are concerned with. But in all the cases the same design paradigm can be applied and actors have to be clearly defined to set to motion the demand-supplier mechanism of problem solving.

4.3 Learning from system dynamics patterns

Suppose that the design paradigm provides us with a satisfactory enough procedure to approach problem solving under complexity. We know, however, that there are designs which are good and others which are bad. The difference comes more from the holistic features of design than from the reductionist ones (the latter being in principle subject to "optimization").

Good designs seem to take advantage of some kind of synergy with the system. This is of particular relevance when the objective of the design is to modify very complex system. The designer should, in fact, in such a case worry whether the foreseen actions are big enough to change sensibly the system trajectory.

Put complexity intrinsic forces to work.

Are not in, the case of globalization, any possible conceived actions too small to hope to produce results in a relative short time? Can we count on "*leverage*" effects produced by the forces internal to the system?

In general, the more we know about the system the higher the possibility to intervene on it successfully. It is therefore important that we understand some basic features of the dynamics of complex systems. However, how can we expect to understand the features of a system which is going through radical changes?

A "conjecture" is that in going through a radical change the system will continue to be "*self-similar*". It might have increased the number of the levels in its hierarchical structure, but the same basic features will be reproduced at the new higher scale.

Apply complexity wisdom.

If the conjecture applies to a "class" of systems we could have hints and knowledge support by observing other systems of the same class. We can use the knowledge of other systems as a "*metaphor*" for the one of our own concern.

The most important metaphor that have been used extensively is that of the biological system. The biological metaphor underline two basic features - "*generation of changes*" and "*selections of the fittest*"- to explain the system dynamic. To these, one should add that the "members" that belong to the system do "compete" between themselves to pass the selection, but implicitly or explicitly they also "cooperate" to be better off in passing the selection mechanism (*co-evolution*). These features are self-similar: we found them at all the levels of the biological scale (from genes, to cells, to individual, to species).

Another important feature of the biological metaphor is that evolution (development) is not continuous, but it goes through periods of stability and periods of changes (*punctuated evolution*): the system cannot change radically unless it has cumulated a large enough unbalance.

We propose that the above self-similar features - "*cooperation vs competition*" and "*dynamic development through unbalances*", together with the design paradigm - will contribute to developing a *wisdom of complexity* that should help us with globalization.

4.4 The Global issues: unbalances produced by the globalization process

The self-similar conjecture of *development through unbalances* will help us to approach the first step of the design paradigm: *what are the problems for which we seek a solution*? This is not a trivial question for globalization.

The evolution of the human system (thanks in particular to technological progress) has been characterized by a three-fold phenomenon: the *increase of the "spatial" span of interaction* among human beings (e.g. by new communication means); the *reduction of "time to interact"* (not only through telecommunication but also through physical interaction); the *increased "reactivity" of the "global" system to local actions* (see the cases of ecological concern).

Globalization can be defined as the undergoing step (the last one?) in this evolution of increasing the "range" (space, time, reactivity) of human interaction to the dimension of the earth itself.

Paradoxically, the ultimate consequences of this change should be that no one is small enough to consider the effects of his action negligible at the global system scale.

The increased range of interactions between system elements is not only a fact that we have to accept but it can represent a potentiality for positive system development. However, this potentiality is not evenly distributed. There is a "*reinforcing mechanism*" (percolation) so that the diffusion of the basic changes of globalization follows privileged paths. "Percolation" produces a separation among the elements of the systems, between the "*integrated*" and the "*excluded*". This will produce unbalances to which the system will later react. The system reaction will be proportionate to the degree of unbalances reached.

The risk is that the globalization process is producing too big unbalances, too widening gaps, between the "integrated" and the "excluded". Is already that the case? In fact, what we call the "*globalization issues*" are actually the result of too great unbalances which have already developed. Unbalances in the uses of natural and artificial resources (such as the S&T endowment), have resulted in "global" negative externalities produced by the "integrated", that interest both them and the "excluded".

This, however, is not the only paradoxical situation of an unbalanced globalization process. Another paradox is that the ones that are excluded from the increased ranges of the potentially positive factors, cannot consider themselves as "small" with respect to the global system. Their actions have also negative global externalities (see the de forestation effects in the LDCs regions) to which the "integrated" react.

4.5 From challenge to action: take advantage of the intrinsic response of the global system

When passing from the globalization challenges to actions, we have to distinguish between the process of globalization and the global issues already apparent. First preoccupation is to help the globalization process to develop in a uniform way *at all system's levels through competition/cooperation* (an application of the *wisdom* of complexity!), avoiding producing other great unbalances.

Globalization is a process that should not intrinsically be considered harmful. Unbalances in human systems increase when competition (or self-interest) is pushed to the extreme without at the same time developing some kind of cooperation.

One possible reaction to reduce unbalance or to stop its growth, is to develop "barriers" against competition. This response will, however, have only transient effects, and, at the end, increase the unbalances. "*General wisdom*" suggests that *the ones that contrast "global" system trends are condemned to be "losers".*
A better solution is, instead, that to favour the system trends by taking advantage of the system "leverage" effects. Our suggestion is that cooperation is the other side of competition and it is intrinsically tied to it.

The competition/cooperation loop, to be effective, has to close at all levels of actions. Instead, there is a tendency to separate the levels where actors have only to compete, from the ones where actors have only to cooperate. [5]

[5] An example comes from the development of urban social environment. In the past, in many European towns, different "classes" of peoples inhabited the same buildings where there were a clear architectural distinction of the different social position of the tenants. However, the vicinity of poor and rich tenants made possible, on the other hand, a kind of cooperation-solidarity to develop (the poorer tenants supplying services to the richer ones). Social unbalances were evident and undesirable. However, the result of shifting the responsibility to close the competitive/cooperation circle to an higher level (through social state solidarity) have produced urban ghettos shifting the unbalances to a much higher scale and making the situation even more undesirable and unmanageable.

Use competition/cooperation at the S&T level.

Limiting ourselves to the S&T sector, we note how important is the competition/ cooperation behaviour at different level of actors scale:

i) scientists compete among themselves to assure individual recognition, while they eagerly present and discuss their results or intuitions with peers;

ii) entrepreneurs will search for *appropriable "localized" innovation change* while in the meantime develop indirect and direct methods to get access to others' knowhow;

iii) cooperation to develop common technological standards is an important features of S&T progress, provided that standardization does not freeze all the freedom to develop new ideas;

iv) S&T planning is a combination of top-down (a sort of "cooperative" effort to single out goals, allocate resources, etc.) and bottom-up (competitive) actions.

Also in the case of S&T we note a tendency *not to close the loops of cooperation/competition at all levels*. [6]

A general recipe to respond to the globalization challenges - which has to be applied also to S&T - is not only to push for more cooperation but *to be assured that competition/ cooperation develops at all system levels.* The problem is particular difficult when proper actors/institutions are not yet developed at the new "global" sub-system level.

To reduce the S&T "*percolation*" phenomenon which contribute to the globalization unbalances, one should recognize the importance of investments on 'intangibles' with priority on education and scientific research. Along with the availability of resources for such intangible investments, organization intervention will necessarily be aimed at increasing the efficiency of the investment, but also at helping the process of change of scientific exploration. Ideas such as developing a 'commonwealth of Science', twining of research institutions, networks of research between North and South countries *have to be encouraged*.

For the Technology side of S&T the 'percolation' phenomenon is even more evident. Application of science for practical purposes tends to be pushed by 'innovators' to get entrepreneurial advantages (localized technological changes). Competition is the basic motivation. Other aspects of the globalization process, such as the opening of the world markets, the increased scale of productions and of size of firms tend to keep the technological knowledge internal to the innovating enterprise.

It is therefore important that one develop *policies to push the cooperation side also for technological development.* Fortunately, the increasing resources needed to develop important innovation changes and the necessity to follow many alternatives research routes to assure final success, push entrepreneurs towards some kind of cooperation (pre-competitive research, joint ventures, etc.).

There is therefore matter for intervention to increase *cooperation in technological development, including networking of companies from advanced and developing countries.*

[6] One instance of separation of the competition and cooperation role is evident in the case of the EC R&D policy: in principle only 'pre-competitive' R&D can be the object of EC initiatives.

4.6 From challenge to action: the design approach to global issues

Globalization has already produced too large unbalances that can be interpreted in term of "global issues". While on one hand one should develop policies and actions to avoid the further growing of such unbalances, on the other hand we cannot wait for the intrinsic (’natural’) reactions of the global system to reduce the unbalances.

Apply the design paradigm to reduce globalization complexity level.

The complexity of the global issues has to be accepted as an intrinsic feature. However the design paradigm tell us that we have to ’simplify’ the complexity by deciding what is the ’internal’ complexity and what can be considered ’exogenous’ to the decision-making scope of action.

’Global’ issues can in fact be classified as issues whose ’complexity’ can be reduced to local dimension, or to regional, or to really global one. According to the different classes, different actors will have to take the responsibility to play the role of client and designer.

The requirement that *the role of the client and of the designer be realized at a system level coherent with the problem ’dimension’* is another aspects of the general rules of avoiding too great unbalances (unbalances between the ones representing the demand and those the ability to respond).

The problem - to find a satisfactory cooperation/competition regime among all the actors interested in the *design response* - is particularly difficult with global issues because any approach to respond with solutions will produce negative externalities as well as benefits. The difficulty comes from the fact that often the one that suffers for the externalities are not the same that benefit from the solution (see the case of transport infrastructure). The definition of what the problem really is and of its ’dimension’ depends from the possibility to close the balance between the losers and gainers from the solution.

There is an important, even if very difficult, plan of action to be undertaken directed on one side to *increase the participation of the ’excluded’ to the scientific research activity,* and on the other side *to shift directions of research*.

For the first part of the plan of action, one should try to put system forces to work by pushing cooperation as well as competition extending to the "excluded" the possibility to "compete" in S&T.

Concerning the second part of the plan - to shift directions of research - the *design paradigm* suggest the importance to concentrate on the organization aspects and specifically on who should play the role of the *client.* The EC has an important role to play as client for S&T and globalization.

4.7 Planning for innovation changes in complex systems.

To deal with the global issues by applying S&T potentialities means to ’plan’ innovation changes. The ’design’ paradigm help in avoiding the trap of considering planning as a ’rational, linear’ approach in problem solving, and in accepting complexity as an intrinsic feature.

First of all we have to accept that an innovation plan rarely could be a one shot operation. Actions might be aimed at developing the ’building blocks’ of future solu-

tions. When this step is performed, the imagined solution might not be possible, because the resulting 'building blocks' are different than originally conceived.

An innovation plan to respond to global issues should make the following assumptions:

1) the today 'global system' has 'slacks' available to adapt to the globalization challenges at least to a certain extent, without having to change its structure or prevailing values (component innovation changes);

2) there are global issues which could not be dealt with unless innovation changes are aimed at sub-systems;

3) the long term challenges of globalization cannot be met unless basic changes in value and behaviour are realized (system innovation).

An innovation plan to deal with global issues has therefore, to be balanced, to include actions that have objectives at the three levels.

4.8 Institutional, organizational and policy consequences of innovation planning

The design paradigm emphasize the client-designer interaction. The difficulty with many of the global issues is that not only they are far from clear, but also that the client is not 'defined' or the role is played by an 'improper' client. To pass from challenge perception to problem definition one will have, therefore, *to make institutional development as an intrinsic part of problem solving*.

The specification of the problem to be solved will depend from the 'client' values, which on their turn will become real values (action inducing) if the client together with the designer can perceive possible solutions.

The design paradigm can be applied here at a '*meta*' level: '*designing the design*' in order at the end to be able to start the real design process having established actors and roles (client/designer) and an agenda of issues classified in terms of dimension (local, regional, global) and of innovation objectives (component, subsystem or system changes).

The examination of few different issues will show better the importance of the meta-design phase.

The deforestation issue. The challenge is perceived as a real one. However there is no consensus of what are the possible solutions. Examining the portfolio of ideas of potential solutions (applying the design paradigm) sorts the effects to point out how vague is the issue that we want to deal with. Is it deforestation an issue because of the potential effects on climate change or on loss of biological diversity, or on both? And what are the priority values: the longer term survival of human kind or the short term improvement of the poorer part of the world? Can S&T help with short term actions that at the same time could reduce deforestation and increase rentability of forest conservation for the LDCs? The looking for ideas now has to be shifted in new directions. The real issues for S&T might be that of finding uses for the natural 'waste materials' produced by the forest, or of how to intervene on forest to increase production of useful materials in a synergetic approach with nature. At the end of the 'meta-design' exercise a panoply of issues with related potentiality of responses might emerge, which could be classified from very long term (needing new direction of basic research), to more practical short term ones (such as develop-

ing more effective mechanical ways to get materials out of the forest without destroying it).

Marginal agriculture. An important global issue is that of inhurbation and abandonment of the agricultural land. The phenomenon produces great unbalances: abandoning of marginal land (such as hills and mountains) in rich countries (with the consequence of decaying biological process and soil erosion); abandoning of potentially rich soil in underdeveloped countries which lack the investment resources needed for an high productivity agriculture (with the consequence of reduced income and of population migration); increasing environmental damage due to the use of pests and fertilizer; reduction of the variety of species because of selecting only the most productive ones; protection of agriculture in rich countries through custom barriers. What are here the real issues? What tasks can be put forward for S&T? In rich northern countries one issue is that of keeping people on the land because of the importance that the human presence has on geo-biological equilibrium. In such a case should the objectives for S&T be that to develop technology that make profitable agricultural activity on marginal lands? Or the objective is different, and one should look for an occupation of the territory for other economic activities with surplus income destined to a good housekeeping of the territory (peasants as gardeners?)? Or, could new agricultural process be developed that at the same time reduce the productivity, assure occupation and good-housekeeping of the territory and also a profitable activity? Can we separate the issues of rich countries and LDCs, or the solutions should be developed in an unitarian scheme?

The agricultural case shows, even more clearly than other cases, how intermingled are economic, social, technological, international aspects; how issues definition depends from values definition and perception of potential solution, from a balanced mixture of competition and cooperation between different society sectors (agriculture, fisheries, industrial, service) and between poor and rich countries, between the ones with food surpluses and the one dying of famine. The '*meta-design*' exercise, will point to radical new ideas as well as to some more short term ones, with related tasks for S&T. *The clear definition of issues and potentiality of solutions will be a preconditions to get the determination needed to allocate resources in so radically new ways with respect to consolidated today approaches.*

Accepting the basic interactive nature of problem-solving, one should consider that each actor in the "loop" not only has to react to the inputs he receives from "above", but also to 'pro-act' producing feedbacks that will change, later on, such inputs. In other words, in an interconnected decision-making / problem-solving situation, there is no excuse for any one actor to stay still, waiting for clear and better inputs.

S&T actors should therefore start their own planning for actions. But how to plan S&T? A plan is always a mixture of a top-down and a bottom-up approach. In practice the methodology suggested is the following:

i) assume that the information on the issues at stakes - as vague and uncommitted as they might be - represents a first sketch of a top-down settings of general objectives and finalities;

ii) evaluate the existing portfolio of ideas classifying them in term that can more easily and directly refer to the globalization issues;

iii) spot, with the help of such classifications, current directions of S&T development that are susceptible of covering the areas of concerns for the given issues and plan for priority actions to continue R&D along such directions;
iv) identify S&T areas of potential interest on which no activity is going on and make an effort to define objectives and ideas to initiate R&D on such areas and domain.

Such analysis will at least provide a way to measure how consistent are today directions of S&T development and the need to change them or the related priorities.

4.9 In synthesis: apply the complexity "wisdom" to globalization

The word "rational" for a problem-solving approach bear an intrinsic analytical/reductionist flavor. To deal with the globalization issues, we need a better and less compromised word. We propose that the approach is better represented by the use of the word "wisdom".

Our basic hypothesis is that "*wisdom*" is available that allow us to deal with complexity. The suggestion is that such wisdom should be applied to the the very complex case of globalization.

From the experience of problem-solving in complex situation we point to the "*design paradigm*" as the one that capture the intrinsic features of complexity. In fact the design paradigm accept: vagueness of problem statement, strong interactions and blurring of roles of the different actors involved. However, it also provide a "recipe" to find ways out from an endless looping of interactions.

We have also pointed out the need to avoid going against system trend and trajectory so to put system intrinsic forces to work. Cooperation/competition is one such system features that should be put to work at all system levels.

Referring to the design paradigm allows to point to very simple general "*wisdom*" recipes (such as that of recognizing the "*dimension*" of the problem in order to choose proper actors) for the behaviour of each actors, even before starting the real problem-solving activity. It also provides more detailed "*wisdom*" recipes for problem solving.

The design approach can be applied to the S&T realm, to develop its role on globalization.

In the problem-solving loop, there is no privileged points to start the process. Responsibility is diffused and each actors can start the process. In particular, S&T actors have a responsibility of their own, reacting to the request from other actors to intervene, but also pro-acting anticipating future requests and even predisposing for such requests to become possible.

5. ORGANIZING S&T RESPONSES TO THE GLOBALIZATION CHALLENGES

Applying the complexity wisdom recipes, we should first of all attempt to define actors and roles. We can consider, somewhat simplifying, three levels of decision makers: the political, the government, the S&T operators. The corresponding responsibility is, respectively: i) to define the values and transform the challenges into specific problem terms of reference, ii) to set specific plans of actions and allocate the needed resources, iii) to design and implement solutions to the problem.

The dimension of the globalization issues often go well beyond the limit of the nations where the sovereignty lies today. Cooperation among existing national institutions might not be enough.

Starting from the EC case, to overcome the ambiguity on role distribution between local and international institutions it becomes essential to define the EC role and the needed transfer of responsibility from member countries. If it is recognized that Europe is the proper dimension to tackle some globalization issues, then EC should play a 'direct' role on the problem.

A first challenge for EC is that to endeavor the 'planning' of S&T to face the globalization challenges.

5.1 The difficult task to develop the S&T potentiality of response

We are faced with a three-fold issue:

- the *non-linearity* of systems (at all levels) induces circularity in problem solving phases (definition/solution/assessment)
- the *turbulence* induced in all human system by globality/ interdependence/ density: will it provokes structural changes?
- technology is both a determinant of the changes and a tool for problem solving: is the general *technological trajectory* going in the good direction?

The difficulties are at the same time ***institutional, organizational*** and ***physical***. The increased interconnections of spatial and social dimensions in the problems to be faced, tend to push problem-solving to higher (spatial and social) levels where the *institutional* actors might be lacking or unwilling to take the burden. To that one should add the *organizational* difficulties at the *physical* levels which are intrinsic to the increased complexity.

No matter how the globalization will effect the world system, there will always be problems that have a local/ national/ regional nature. It will be a wrong depart - for problem solving - to shift problems from their proper dimension to a larger one. It is part of the *globality issue* to succeed in separating real world scale problems from those that pertain to lower level classes. But even the lower class problems have become more complex because of the increased "global" interactions and of systems saturation.

A *well known recipe* that any control engineer apply when designing the control system for an "hierarchical" complex system, is that of *closing as much as possible the feedbacks locally so to reduce the role of any central control.* The derived general

recommendation is: *to solve the problems to be faced, keep them to the level where they pertain.*

Organizing for S&T intervention will be different according to the class of the problem and especially according to its *"dimension"*. The S&T contribution to be effective might have to be accompanied by other measures, such as: create new institutions, set incentives, impose constrains.

S&T tends to progress on "natural trajectories" which not necessarily go in the direction of developing potential solutions for the problems we have to face. A focal point to help defining a realistic S&T policy will therefore be the understanding of the intrinsic characteristics of S&T dynamics, the obstacles and inertial trends of *technological trajectories.* We might be in a unique position in history to approach the globalization challenges if we are approaching a transition. For technology, one should revisit the Kondratiev cycle. For geo-politic, the regionalism might help in institutional building.

However, the difficulties to apply S&T might be outside S&T, and lay more on the ability to approach non-linear system problems, starting with the institutional issue (who take care of the problem?).

This problematique have a direct impact on the EC case. S&T policy-making at the EC level should distinguish between the type of intervention:

- regional problems for which there is a not-substitutable specific role for EC,
- contribution to lower level problems which have strong commune characteristics,
- participation to higher level (inter-regional/world wide) problem solving.

5.2 Dealing with circularity in problem-solving.

Unless the challenges are translated into clear *remits and policy-mechanisms* the role of S&T will be difficult to develop.

S&T could itself help in defining *"remits"* (by exploring technology-push idea on possible solution of not yet completely specified problems). However, to deliver S&T potentiality, it might be necessary to revise the S&T agenda and organization.

In considering R&D actions one should also not forget the market dimension and remember that two are the mechanisms of intervention (market and non-market mechanisms). Indeed, one of the difficulties with many intervention in LDC's is that there the mechanism are prevalently of non-market type. An efficient S&T policy should therefore at least support both mechanisms.

One should not take for granted that - once we have agreed on the priority of the problems - we could proceed with the problem solving. It is also a question of how to proceed in order to assure an efficient response, how to deal with the circularity introduced by non-linearities.

There are **two types of loops** in problem-solving when dealing with complex system. One loop is due to the "*fuzziness" in the separation inside the system between the sub-systems and, outside, with the system environment*. A problem which emerges at a given system level tend to involve other subsystems or shift at a higher level or invade the "environment". This type might be called a ***"dimensional"*** loop.

The second type of loop is proper of the complexity of the problem-solving process

itself with its different phases. It might be called ***process loop.*** The design approach is a practical response, provided we succeed in framing the issues to be solved.

The process loop.

During the phase of *"problem-definition",* when one "feels" a problem - as an actor in the system - he feels it at his specific sub-system level. The first obvious pragmatic approach is that a solution should be find at that level.

Suppose, e.g., that the one that feels the problem is a "user". What should be his contribution to problem solving?

The scope of the intervention from the demand side - in line with the actor's role - could be in principle classified as pertaining to the phase of "problem definition". The successive phase of searching for and developing a solution (the design phase) should be dealt with by the ones in charge (at all the levels interested). However the conceptual separation between the two phases is an abstract one. One cannot proceed in defining the problem unless one sees the type of solutions which might be developed.

The actors representing the *"demand"* should start the process contributing to better define the *"demand"* for a problem in need of solution. In doing so, they might soon discover that the level of the problem shift to a higher one in the problem-solving process: to that of looking for "problem solution". The higher the level, the less "comfortable" will feel the one who denounced the existence of a problem at his lower level of operation.

The more one tries to focus the problem indicating practical needs and means, the more the problem become fuzzy, the level of consideration shifts from a sound known ground for the actor to a more vague or academic one.

The difficulty for problem-solving goes therefore back to the first type of loop (the "dimensional" one). In other words: *can we focus on a specific "component" of the system where we think that the problem has its roots and deal with it isolating the component from the system?* For this to be possible, a prerequisite is that the *system structure be stable.*

The more one is following the looping in the iteration process, the more one will be convinced that he cannot avoid to pass to a more general "dimensional" level in search of the right dimension of the problem, which will make more simple and effective the development of solutions.

The problem-solving process-loop problematique involve also the phase of ***technology assessment.*** The TA actor enters into the process from the end side. His responsibility is *to alerts on the cost and externalities of the intervention which is decided* (design phase) to respond to the problem challenge.

The TA activity should be intermingled with the two "preceding" phases of problem-definition and solution-designing. The TA for a project could be considered as a way to make another iteration on the problem-solving circle.

The case of infrastructure can point to some interesting phenomenon. Here it emerge clearly, a kind of **"*system paradox***" that make decision-making so more difficult and inefficient today with respect to the past: *while the "negative externalities" are mainly "localized" in nature, the beneficiaries of the infrastructure are more and more dispersed on larger area.*

This paradox *(the cost an benefit does not close on the same group of interested members of the society*) can be extended to many other cases.

The dimensional loop: to class problems according to their dimension

To react to the difficulties raised by the *dimensional loop* one should insist on properly classifying the problems according to their *dimension.*

Local problems. Let us consider firstly *problems which are classed as "local".* According to the proposed general recipe, one should try to keep problem solving at the "local" level, no matter how much its complexity is increased by the increased "*global interconnection*".

To translate this into policy, one should *help the local actors to have a more "aggressive" approach to problem solving:*

- entrepreneurs should not cease to look for the peculiarities of local markets and try to exploit them by proposing/creating products that fit local needs;
- public operators should not be discouraged by the difficulty to deal with intervention on, e.g., territorial issues.

S&T can help in general by:

- a more flexible technology that permit to assemble products using standardized (generic technology) components (which will benefit of large scale production),
- applying the systemic approach in problem definition and problem solution (for market products and for public systems),
- developing a new "wisdom" (from complex non linear system theory) with practical recipes to help public operators in decision-making.

Setting S&T policies and developing actions to help local actors is, however, seldom a local responsibility. In general, the responsibility of the higher level, such as the EC in Europe, will be that to intervene to *change the global context* to make easier and more profitable local initiatives.

Regional problems. Often the problems that emerge at regional level are old local problems that have reached the new dimension because of increasing interactions.

The institutions at local level (national or provincial) might see a power issue connected with the dealing of problem solving and therefore resist to transfer it. The more so, the more a local approach is possible even if much less efficient. The air traffic in Europe is such an instance, or the development of high speed train network.

For S&T to help, a "customer" for S&T is needed. In many regional European cases there is a basic role for the EC to intervene. However, instead of claiming that a basic role for S&T policy in EC is to deal with the regional problem solving, the resistance of the member countries has made prevalent the idea that the EC research policy should mainly be *"complementary"* to the national ones. Paradoxically, it might be easy for the EC to develop consensus to deal with "world" level problems (which might be proper of other institutions) than with European regional problems.

S&T has the tools needed to play an important role: a revised approach to "systems" valid for non linear ones; system modeling; large scale experiments; the "new paradigm" of a technological regime based on the diffusion of "enabling" generic technology.

Concerning the problem definition phase, *S&T can help in showing* that there are potential and better *solutions* for problems if dealt *at the proper regional level*. It will thus help to set in motion the highly difficult process of *shifting problems from local to regional* institutions.

Common (universal) problems. Another class to be considered is that of problems which, while being local or regional in nature, present strong similarities from one region to the others. They are not "world scale" problem, but they are *"universal" problems.* Even when the local or regional conditions are very different from case to case, there are at least some preliminary phases in the problem solving that have strong common features. One case to the point is that of sheltering.

An important contribution to globality is that of *sharing resources to approach common problems.* The basic reason is not, or not only, that of solidarity from the rich regions to help the poor ones. Instead, the basic determinants for cooperation is the increasing number of problems to be faced at all levels.

The cooperation in S&T will produce another important result: that of increasing the opportunity to develop universal standards and generic techniques/components that could be flexible (integrable with different local "residual" technologies).

While, generally speaking, the present situation in *EC R&D policy deals more satisfactory with "common" problems than with "regional" ones*, a more detailed analysis is needed (e.g. to clarify to which extent the requisites of *"complementarity"* and *"pre-competitiveness"* are not limiting the choice and the priority setting of common problems).

World problems. The first important contribution will be that of listing such problems. Because of their novelty, *the definition of what exactly the problem is* (before trying to solve it) might already be a difficult task. Here R&D can contribute with system research.

In this category one may list *problems which are generated from special "subsystems"* which have developed to a world scale thanks to the technology itself (e.g. international finance).

One such case has to do with research itself. The world wide diffusion of basic science (in the sense of lowering the threshold to use research for evil ends), produce new problems (ethical, security) that the "global science subsystem" is not able to control by itself.

Another class is that of *old problems which have shifted from local/regional to world scale.* Some problems in this class are on the international discussion table since many years, such as that of the exploitation/ conservation of marine resources. *"Cooperation among equals"* seems to be, here, the only possible approach, at least in a transition phase.

What one expect from research (even more here than in the regional case) is to show that there are *approaches which are only possible at global scale* and more efficient than "aggregating" lower level solutions.

To make more concrete the development of international cooperation, one need to dispose of *a portfolio of idea on problems and potential solutions*. Such portfolio to be developed, requires resources and initiatives. And there is space for *EC to take such initiatives* in cooperation with other regions or on its own.

A further class of problem are those that might in principle be considered local/regional in nature, but becomes *world problems either because of human solidarity or fear of catastrophic* consequences at world level as a result of not solving the problem.
Satisfying basic subsistence needs for the South of the World is one such problem. Can S&T help and how? The general development of technology can go in the right direction if a *technological paradigm of a more generic (universal) technology* will develop. The basic idea is that of a flexible technology which shares at the higher design level the advantage of *"systemic approach"* to pass from needs to problem definition, to solution. Flexibility should be assured also by an *hybridable* technology, by this meaning that advanced standardized components can be integrated with local less advanced ones.

5.3 Planning the S&T contribution

We are confronted with the basic antinomy, that planning means to break down the 'whole' into pieces, while non-linearity means that such breakdown destroy the object we are investigating. We cannot however renounce to planning actions.

The *bottom-up "planning"* for S&T is actually an outcome of the trends of undergoing R&D activities aimed at exploring the future.
The amount of real planning (the *teleological* forces that motivate the R&D) of such activities might be compared with that of an explorer searching an undefined "treasure" in an unknown territory. The success of past and undergoing R&D exploration reinforces certain paths. The broader the R&D activities, the greater the number of exploration paths followed and therefore the greater the probability that they will lead to innovation that meet the challenges to solve new or old societal problems. It is because of such exploratory innovative activity that S&T can contribute to the very important first phase in problem-solving by a portfolio of ideas and suggestions.

Top-down planning starts with clear indications of the needs and it should teleological prescribe activities to meet the specified objectives. However, planning has to take care of the inertial trend of technological trajectories. If the direction of planned activities are in contrast with such trends it might be quite difficult to accomplish the planned tasks, or it might require very *long-term* and *indirect* activities. Fortunately, there are periods in which the direction of R&D trajectories becomes blurred, different trajectories converges and new alternative directions might utter. The long-term technological waves (changes in technological paradigms) open important opportunities for top-down planning.

Real planning is possible only when the 'pieces' that the plan defines as necessary to reach the ultimate objective of the plan are already there. Since we know that we cannot have this type of assurance, the trick is to start with a grand scale view of the system so that details (the lacking pieces) are not perceived. The system will appear as made up of large building blocks, to which we can assign names, functions, performances objectives. When the planning at such a scale is done as a first tentative step, we could then go to a smaller scale and try to identify the components that are necessary to make the system building blocks, and so on.

The procedures should of course be reiterated bottom up, to adjourn the plan as the smaller pieces are there as expected or quite different. With this procedure the plan becomes actually a kind of *meta-design of a complex system.*

Hierarchy in objectives

The objective of an S&T plan is to innovate a given system. The innovation objectives might however be limited by the plan to consider only possible changes at the lower level of the components, or at the intermediate subsystem level.

It is important, in order to contribute to the S&T policy definition to be able to distinguish the *"hierarchical" level of the innovation objectives*. This goes together with the need to distinguish the geographical "scale" of the problem (local, regional, world).

Starting form the lower level (the **level of "components"**), the innovation objectives take as given the general structure of the global system as well as each subsystem structure. *The scope of innovation is limited to improve the performance of the interested components*. In such a case the technological *"innovative" objectives* might be quite precise and s*et "quantitative" targets* assuming a certain "determinism" in the technological development.

The objectives of innovations might be placed however at a higher level in the system, aiming at changing the way with which each **subsystem** is *"structured"* to perform its role and functions in the global system. In such a case only the system structure is taken for granted. The ability to change an entire subsystem usually needs a longer-term perspective and the consideration of different alternatives solutions for the subsystem structural design. The *objectives* in such an instance will be less quantitative and more *tendential* (specifying only the general characteristics of the expected innovation).

Finally, if the planned changes regard the **system itself** (the system structure is not taken for granted), then an ever longer-term approach is needed: changing the system structure is possible if new subsystems can be conceived to perform different functions (than the current subsystems). The *objectives* have not only to be very *flexible* (express trends more than quantitative targets), but they have also to be *"normative"*. In other words, the objectives have to intervene at the level itself of the *"values"* of the researchers.

Considering the hierarchy on the objective definition, we can refer to the corresponding **situation** (context) to which the **"decision-makers"** are confronted. In the three cases the context is, respectively: *tactical, strategical, political (valueative)*. The decision-makers should be able to deal with the respective situation.

Typology of design activities and S&T contributions

To meet a given challenge, the actual difficulties to pass from problem-definition to solution-searching increase from tactic, to strategy, to policy objectives.

One could say that the **design** ability should respectively be: *configurational, systemic, structural*.

Configurational design means to be able to develop new or improved product by using existing "hard" and "soft" components to assemble the conceived product.

Systemic design means to start from a given system structure aiming at designing completely new "subsystems".
Structural design means to start anew at the system level by designing the layout itself of the system as made of new subsystem.

The *challenge for S&T* contribution can now be better understood.
R&D can be called in to contribute new idea at the component or subsystem or even at the system level. The results might not have already to be there to make possible to pass from the challenge perception to the problem definition. However the decision-makers should be confident of the possibility of success even if one should wait for a long term to see it

Different phases of research (basic, applied, development) might all intervene with specific contribution to help decision-makers. So, e.g., there are policies for ***basic research*** dealing with the tactical, strategical, structural level of the contest.

S&T policies should consider the other context factors which are relevant for a successful action planning. E.g., for less developed countries S&T policies might be more consistent with the countries general context if they give priorities to tactical objectives, launching configurational design projects to develop new products (taking advantage of the hybridization potential of existing advanced components).

All these interventions depend on the ability to organize not only the *offer* but also the *demand* of S&T. in fact, the creation of portfolios of idea depend from the S&T demand.

One should also note a strong interdependence with the institutional situation. ***The case of EC*** is of special importance. Through the Framework R&D programme the EC has formalized the demand. However the EC situation resent from the difficult trajectory that has been followed by the EC instances to build such a demand.

In **conclusion,** the difficulty of the planning concept exists at any level of the S&T system. It might be a very simple plan to improve a product components, but still the basic intrinsic difficulty will apply. There is a kind of *'complementarity principle'* to be taken into consideration: *the higher the system level where we place the objective of innovative changes, the longer the time scale to accomplish the plan, the greater the number of top-down / bottom-up loops.*

5.4 Technology and multipolarity: A robust design for S&T policy.

Will technology lead us to look for a world market of world products? There are technologies - like information and telecommunications - that contribute to develop strong ties that envelop together the world as a unit. For some technologies (e.g. telecommunications) uniformity of standards and products is a requirement. However, there are other factors - human, social, economic as well as technological ones - that will maintain multipolarity as a basic feature.

A realistic scenario of globality should therefore accept that the emerging world system is a multilevel and multiregional one. In a *multipolarity world*, products specifications should respond to the specific user needs.

A flexible technology scenario

If we are permitted to follow the ***biological evolution metaphor***, we can envisage different technological "species", each one going back to common "families" deriving all from a unique technological "trunk". The scientific knowledge will be the base of the common trunk. Materials and some "generic" technologies and components should also be included. But at the other extreme - that of final products and related production processes - technology should show the ability for a flexible responses.

We are well aware that product specifications changes with time to fit the changed, in the mean-time, users' habits and needs **(time-wise** product variation). In a multipolar world, modern and progressing technology should be able to deal as well with the concept of a **spatial-wise** product variation.

The ability to design products to fit specific "regional" needs will therefore be of prominent relevance in a *technology flexible scenario*.

From the technology trunk, "families" of components and subsystems pre-adapted to specific market needs will emerge to make possible an efficient and effective tailor-making of final products and production processes.

The concept of a "multipolar" technological response to a multipolar world will strongly influence policies, strategies and actions at all levels, public and private. The concept does not contradict the trend towards more "global" ("networked") enterprises in services and industries. It poses however the problem of their "scope" of production and of the organizational responses. Will *"global" enterprises* deal only with global standard products/ processes (materials, components, and - only in limited special sectors - final products/services)? Or, will they organize to respond with flexibility to the local needs by adapting the product /process design?

Generic and localized technological change

The dualism between 'global' and 'local' products/technologies can be correlated to that between 'generic' and 'localized' technological change. The policy dilemma here is between favoring 'generic' innovations to enlarge the access to the S&T potentialities, and the 'localized' one to increase the appropriability to local entrepreneurs as a prize to their entrepreneurship.

Can we at the same time increase the homogeneity of the global system as well as the differences of local actors, the exploitation of soft and hard factors? The solution is to recognize that there is a common interest of potentially adversaries to change the global context in order for each one to be better able to valorize the local resources and their differences. If one look at the S&T endowment, one should aim at increasing the base of 'generic' technology on which more 'localized' technology can be developed.

Reconsideration with respect to past failure in adapting technology to local needs and cultural and economic context, is possible because of the general technological progress: namely the increased reliability and the possibility to design for long life without the need for maintenance. Because of the high reliability of mass produced standard components, it is possible to develop technological recipes that assume that the components are "black boxes" of which one should know only the

performances and be assured of their operational reliability. This model will fit with the law of the *increasing variety of technological responses of a system increasing in complexity* which should strongly influence the strategic thinking:

- ***for enterprises***: how to assure a "needs pull" variety of product responses,
- ***for public actors***: at the R side of R&D, how to balance resource distribution between the basic research (global) and the applied research ("local" priorities). At the D side, how to define objectives and terms of reference for "finalized" projects to help technological innovation to follow "needs pulled" trajectories.

Robustness of technology to scenario variation

The above model of technology diffusion could help in approaching the important question - which is a preconditions to define S&T policies for globalization, - of the "sensitivity" of alternatives of "global" scenarios on technology. So, e.g.:

- in a *triadic scenario* - which favors global product and process standardizations to fit the highly competitive open market within the Triad - the metaphor of the "technological tree" will lead to a great ’trunk’ with few small branches (technological niches);
- in a *multiregional scenario* - which will see regional protected market with products and processes responding to the region peculiarities - technological "species" will develop as final ’branches’ and ’leaves’ of the technological tree. However the tree will have strong "regional" branches while the common trunk will be reduced in height;
- in a *global cooperation scenario* - which will aim to satisfy the tremendous basic needs of the Third World - we might see a stronger but shorter trunk and short first branches with a high number of final branches and leaves. Emphasis on R&D will completely change at public level and industrial technological strategies should consider the challenge of how to integrate production with local resources.

What is interesting to note here is that there is a base S&T policy common to the different scenarios, that will permit a *’robust’* (insensible to scenario variations) policy design. Namely a policy that will help to increase the accessibility to the S&T endowment, no matter how much it has been built following ’generic’ or ’localized’ technological changes. Such a policy should aim at making acceptable ’localized’ technology by packaging it as a ’black box’ easily integrable as component in new product/process systems.

Such ’integrability’ should be open to *’hybrid*’ product/ process concepts, where components/ technologies of different level of technological advancement coexist (see the problem of ’adapt’ technology for the LDCs).

Part III PROPOSAL FOR ACTIONS FOR EC

Globalization represents a change in human system complexity. To deal with it, it is necessary to assure variety of responses and flexibility. What the EC can specifically do to approach globalization and global issues?

We need a creative approach on all the components of the action process: from value setting, to organisation, to problem definition, to solution design. The appeal to act should go to the different actors at all the level of society organization: political, governemental, S&T and economic operators.

Because of the uncertainties even in the definition of what the real problems at stake are, to assure a variety of approaches is more important than the attempt to select priority issues or to better focus the actions. We need to learn how to deal with the globality issues: so the approaches should assure, through variety and flexibility, that even errors will contribute to such learning.

All that makes difficult to converge the necessary will power and resources to develop practical actions: in fact we are too used to consider that action programmes should be well spelled-out and assure the selection of priority. We should therefore have the courage to admit that a clear and well focused programme will be misleading.

*What we need is an **experimental approach**, vague enough to assure the creative contribution from different sources, and the possibility to make change of directions and priority as we learn from the progress of the actions.*

The current EC R&D FW Programme need to be revised to adapt it to the globalization preoccupations. However, actions cannot be limited to such a revision. To avoid a too centralised approach it is important that a proper climate be developed to alert on the needs for multipolar interventions, to provide for leverage effects on actions (no matter where they come from), to assure a frame of reference for debate, co-operation, stimulation.

With that in mind, we can underline the important role that the EC will have in providing such climate to induce actions.

Specifically we recommend four main lines of actions: promote a "vision of the world" that will set the values and frame specific actions; recognize the role of science for policy development and take consequent actions to assure the contribution of science to EC policy initiatives; reoriente the current and the forthcoming R&D FW Programme to open it to the concern for globalization issues; start an experimental specific programme on globalization giving concreteness to the role of the EC as *client* for globlalization.

6. PROPOSING A CO-EVOLUTION VISION OF THE WORLD

Applying the basic recipe suggested by the *wisdom of complexity*, one should first of all assure a "vision of the world" on which to frame any decision, so that intrinsic system forces are put to work. ***We suggest that "co-evolution" is a basic intrinsic characteristic of system dynamics.*** Co-evolution means assuring that competition is tied to cooperation at each of the many levels of the system.

We will spell out the consequences in terms of S&T policies. The technology development trajectory does not intrinsically contradict the apparently dualistic targets to favour global cooperation to change the context, while increasing competition to valorize local diversities. An appropriate S&T policy (favoring at the same time 'generic' and 'localized' technological innovations) will help putting S&T to work in the desired direction.

The approach can be applied to a unique global world-wide context. However, it will be much easier, in practical terms, especially considering the state of the geo-political scene, to apply such S&T policy at macro-regional level - one of which should be built around the EC - in a multipolarity world scenario.

6.1 A realistic approach to Multipolarity Scenario: the Enlarged European Region

The building of the European Community could be considered as a systemic change which has been at the base of the economic and social progress in Europe in the last decades. The basic reason to consider a scenario for an enlarged European region is to look for a new positive systemic effect that will increase the overall possibility to respond to the future challenges by the countries in the region. If the region includes the southern Mediterranean countries and the Eastern Europe ones, the success of the project will be a very important contribution to the globality challenges.

The difficulties to push for such a venturesome scenario are, among others, related to the difficulty to recognize how much the success of individual European countries in the last decades is due to the European Community (co-evolution effect). The moment, moreover, seems to be particular unfavorable, if one consider the parochialism that seems to emerge and the quarrels on the cost of solidarity between the central and the peripheric parts of the Community. On the other hand, a simple extension of the Community as such might not be feasible, considering its already large heterogeneity.

Therefore a different model - which pushes at the same time homogenization and diversity - has to be developed and proposed in considering an extended European region. The model proposed ***accepts the theory developed by M.E. Porter*** (The Competitive Advantages of Nations) *to explain the successful case of different countries economic development* ***but it includes the effect of the regional environment.***

To the basic claim of Porter's analysis that the *development is bounded to very local conditions* (the competitive advantages of each countries) we will add - on the basis of the Community case - the *existence of a positive synergetic effect of* ***co-evolution*** *for the countries tied together in the region.*

While it can be considered that the progress in the building of the EC has successfully completed the opening of the market, it is still far from having **"homogenized"** the **"space"** (infrastructures, services, etc.) and the public policies towards business. The co-evolution development of each EC country might therefore find new stimulus from the further phases of the Community construction (economic, monetary and political union).

However, can one forecast that the realization of an enlarged Europe region will become a positive-sum game for all the partners?

The selling point for the scenario of an enlarged European region will be that within the enlarged space of the region and because of the variety of the included realities, it will be possible to develop successful policies to help the forces which are, according to Porter, the determinants of economic and social progress.

The diversity asset. The first consideration to be underlined is that "diversity is an important asset" to be defended no matter how much one is convinced of the positive effects tied with the "globalization" tendencies.

In the case of EC, to appreciate this statement one should look at the situation from an *"European standpoint"*. The formal completion of the Common Market will set in motion new intrinsic dynamic forces that will have effects on the European space utilization. The problem of the *changes induced in the peripheral regions of the Community* could therefore not be understood, unless they are considered within the more general frame of the dynamics of the European space. The frontier regions between EC countries might be the first ones to show signs of change. New socio-economic attraction basins might develop around the so called "eurocities", without too much respecting the old separation induced by the state frontier.

The enlarged space and its increased homogeneity (infrastructures, standards and regulations, etc.) will provide an environment that will facilitate the opportunity for the *local diversities* to exploit their differences.

The co-evolution pact. The basic aim of the Enlarged Europe scenario will be *to assure through* ***co-evolution*** *the possibility of each participating countries to make the maximum use of the potentiality* of their competitive advantages and, in any cases, to create the conditions to start virtuous cycles to create wealth.

The agreements among the partners should permit to reinforce local policies aimed at favoring the realization of the four conditions considered in the Porter theory. Let us look at each one of them:

- *to create an environment which will facilitate the entrepreneurial activities*. The extension of the region might make possible to *create networks of infrastructures with higher efficiency and or with new technology*;
- *to assure an internal market relevant and sophisticated*. The agreement on a free trade area poses difficult problems for contrasting interests. A new vision might here be necessary with respect to the current tendency, for the emergent countries, to consider relevant only the already developed market of the richer countries.

The common aim will be to start, even in the less developed part of the region, a phase of ***development stimulated by innovation*** (jumping over the phase of using the productive factor advantages for already existing markets). [7] *Innovation will have here to be intended as oriented to develop new products responding to local needs*;

- *to deepen the clusters of producers for each sector of products*. In fact, one should expect that the larger the region, the deeper the clusters (increasing number of customer-supplier links in the production chain);
- *to increase the business-government alliances* to help developing more aggressive business strategies. As difficult a point as it might be, one should however expect that on the longer term Schumpeterian creative destructions might be easier to develop on a larger region.

6.2 S&T policies instrumental for building a co-evolution scenario

The realization of the co-evolution regional scenario requires a clear vision of opportunities and difficulties, and to ***design for a soft trajectory to the final scenario*** with priorities changing with the different phases in the trajectory. The "pact" between the partners of the Region will have to reflect such a clear vision and spell-out objectives, procedures, specific projects of cooperation.

The Porter's four basic determinants of the competitive advantages of nations can provide a frame to underline the S&T role:

- *influencing the condition of productive factors, by **creating** productive factors*:
  - look for "missing network" in the infrastructure
  - improve education and formation,
  - incentivate S&T cooperation,
  - help creating new local "nuclei of condensation" of innovation activities;
- *influencing the condition of the demand:*
  - promote advanced technical standards, and product/process regulations,
  - develop advanced information services to users
  - launch public projects for advanced new products development;
- *influencing business clustering*:
  - favoring the integration of industries to develop new products,
- *influencing the strategy, the structure and competition between enterprises:*
  - facilitating projects for foreign investments.

The role that S&T can play in practice will depend of the willing of the partners to recognize the importance of S&T as an agent to favour the co-evolution.

The basic proposal here, is that the EC take the lead to propose a *vision of the world* that considers EC as the core for an enlarged Europe region that will contribute to respond to the globalization challenges starting from its internal challenges: first of all that of assuring that cooperation develops as a counterpart of competition.

Concretely, the EC should develop policies along the above listed lines, to facilitate *system forces to work* to realize the desired scenario.

[7] Porter has proposed a typical trajectory: from a phase of development stimulated by the *producitve factors*, one passes to one stimulated by *capital investements* and then to one based on *innovations.*

7. INTEGRATING SCIENCE INTO POLICY MAKING

7.1 Building a Science for Policy branch in the EC [8]

Global environmental challenges facing the international community are pressing toward a more active EC role in international issues. However the reality of the European international environmental policy - as shown by the negotiation of the Montreal Protocol for the ozone layer problem - was markedly at odds with this requirement. In EC the combination of factors that pressured US Administration to take regulatory action was lacking. Environmental groups, media and public opinion were far less concerned than their American counterparts with ozone layers protection.

New effectiveness in international environmental policy needs a shift in EC decision-making procedures, the Commission being allowed a more active role in this issue.

The inadequacy of a "science for policy" at the EC level, leaving aside the national ones, was apparent in the ozone negotiations. Largely diffused was the opinion, especially among the US negotiators, that EC Commission was greatly relying on corporate advice as a result of a close cooperation with industry.

The ozone case, from the European side, revealed the emergence of scientific advice as a major policy problem the EC has to solve in coping with global environmental and resource issues. Existing tools are at present totally insufficient. Astonishing as it may be, the EC has no clear instruments for scientific advice. As a consequence the *building of an effective science for policy* branch is to be viewed as a primary institutional arrangement that would be required to address major environmental challenges at regional and international levels.

First and foremost, it would be necessary to make expert community and scientific advice institutionally better represented in the EC policy process.
EC lacks a system of expert agencies - the US Environmental Protection Agency (EPA), can be an example - able to provide regular and predictable interactions (through a variety of standing or ad hoc Advisory Committees) between the scientific and technical community from one side, and the policy process at the other side.

The build up of a European Environment Agency (EEA) - recently devised at the environment ministers level - must be implemented to enhance the quality and independence of scientific and technical advice on these issues.

It would be diminishing to depict the advisory process simply as pursuing the task of releasing scientific or technical well assessed information. The blurring of the boundaries between scientific and political items particularly in complex socio-technical issues, has made *the procedures for advice-giving more central in the process of policy formulation*. Expert advisory committees can play a crucial part in bridging scientific knowledge and policy decision. The effort to build a consensual view among partially divergent scientific viewpoints can in turn influence policy.

[8] This section is a condensed version of the contribution by V. Ancarani to the report CSS/fast-10.

The proposal here is that the EC take specific initiatives to develop proper instruments to avail itself of the science support for policy development.

7.2 Revisiting EC Policy for Science

It will be difficult to adopt an EC *science for policy* for globalization, unless the other side of the coin - *policy for science* - is well developed.

To show the case in point, one should go back to analyze the peculiarities of the EC involvement in R&D. It all started with the Euratom Treaty as a kind of 'joint venture' between the member countries to develop an ambitious project.
Once the organization to respond to the Treaty mandate was set up, it posed immediately the problem of the relationship with the national nuclear research programmes. The solution found was to identify a specific research route (a reactor design concept) different from those followed by the member countries. It was the first practical development of the ***'complementarity'*** *principle* that will characterize all the future development of the EC R&D activity. In fact, when new sectors appeared of importance for a Community intervention of R&D - such as the energy issue following the oil shock - the common decision to cooperate, when implemented into practical programme terms, was kept into the limit of the *complementarity and non duplication* with respect to the national R&D programmes.

The simple question of the ***demand-offer*** problematique for the EC R&D did not clearly surfaced in the Community debate. Is the EC representing a 'demand' for R&D, because of the specific subject matters which are recognized of EC responsibility?

The specific proposal here is that the EC instances take the opportunity posed by the need to react to the globalization challenges to ***revisit the base of the current Policy for Science.***

If there are fields for which the member countries have delegated authority to the EC, shouldn't for such fields be delegated also the responsibility to define the demand of R&D? What is the rational for the EC to have intra-mural research (the Community Research Center) after the practical ending of the common nuclear project? As the national cases show, there are many reasons to justify the presence of public institutions on the 'offer' side of R&D. However, are these reasons made explicit in the case of the EC and consensus reached among the member countries? The fact that there is a *'direct' EC demand for R&D,* does not however implies that the response to that 'direct' demand should be provided by *in-house research* organization. [9]

Can we say that today the R&D FrameWork Programme is a right balance of bottom-up and top-down planning? The answer might be formally positive. However one gets the impression that serious barriers to a real top-down plan of the R&D activity comes from the lack of basic discussion and agreement on the 'direct' role of the EC in matters that require R&D support. The enhancement of the new principle of "subsidiarity" (roles division) must change the situation.

[9] One should recognize that a rethinking of the missions and scope of the Joint Research Centre have started and has already led to a deep restructuring of the Centre.

*Globalization could represent an important opportunity to relaunch the frank discussion on the '**why, what and how**' of the EC intervention in R&D.*

In fact, globalization compels to pose the problem of the 'dimension' of each of the issues (whether they are local, regional or world wide) and to develop an institutional approach to the problem solving at the proper dimension with respect to that of the issue. So, if there are problems that have an European dimension, the responsibility to deal with such a problem should be developed at the European level.

From an approach to EC R&D that have mainly responded to tactical objectives (avoid duplication, choose projects that cost less if performed on an European scale, etc.), one should go to:

- a more ***strategical approach*** such as to develop a portfolio of ideas and solution that are intrinsically at the European level,
- a ***policy level***, to define the issues and their priority, to allocate the needed resources, etc.

8.1 Identifying priority R&D programmes for globalization

To be able to produce protocols for action-prone R&D policies we need to start defining specific problems to be addressed. To deduce a scale of priority we need a reference grid to help translate general preoccupations into specific terms of reference for problem-solving actions. The following procedure is suggested:

- ***set up a list of globalization challenges and make a first identifications of related objectives*** defined in very general terms, such as: protect the environment, relieve poverty, improve the quality of living in urban ghettos, etc. The challenges could be divided in two broad categories: *vertical* and *horizontal*. The former are the challenges which can lead to organized actions to meet specific objectives. The horizontal challenges are instead those which aim at improving in general the capability of mankind to deal better with the globalization challenges in general.
- ***for each challenge so broadly defined, identify and specify the related issues and problems***. Usually, more than one problems relate to a broad challenge. To identify, specify and translate them into S&T action programmes is not an easy task. It will help in the process of problem-definitions to remember that problems might emerge at *local, national, continental, world-scale level*. This point of view in challenges/ problems identification has the advantage to be easily correlated with actors/ institutions that could act as decision-makers.
- ***For each problem area so specified (which are related to a given general challenge), one should plan R&D, engineering, operation actions.*** Since no problem is really completely new (a lot of different activities might already be in progress at different levels and looking at different aspects), top-down planning will be possible deriving the *demand for S&T* from the *"state of the art of action-taking on the challenge"*. Once the problem is reasonably defined, S&T can help in providing suggestions for alternative development in solution-implementation. This step of the *S&T planning process will lead to two major categories of programmes:* the ones that look at *exploiting the existing S&T capabilities and ideas to respond to the specified needs* and the others aimed at a general *calling of S&T to provide a portfolio of new ideas* leaving large freedom in exploring the potentialities of the S&T endowment. One can refer to planned S&T for the first and to exploratory S&T for the second.
- the planning process will not be effective, unless at ***the higher level of policy-making, the priorities of challenges and problems*** will be identified and, ***the degree of innovation changes desired or permitted*** defined *("configurational", "systemic", "structural"* innovation change*)*. The different innovation policies will, respectively, (in the reverse order) respond to the willing to change the *"values"*, the *"strategic approach"* in problem-solving, the *"tactic"*. It is important that the *S&T programmes be labeled with the "degree of innovation change"* looked for.

The effort of classifications will serve a double purpose. On one side it will have a ***creative effect*** *in problem identifications and specific action proposal*s

for S&T programmes. On the other side, it will help giving meaning to priority setting at the policy level by ***allocating the limited resources*** *according to general principles* (valueative, strategical, tactical) and not only to the ranking of challenges.

It is proposed here to prepare a list of R&D projects to attack the main globalization issues. The list should be aimed at soliciting the process of change and reorientation of the R&D FW Programme and to start specific new projects.

In Appendix a preliminary list of R&D programmes defined applying the suggested procedure is described.

8.2 The required changes in the current EC R&D FW Programme to open it to globalization concern

It will not be possible to approach with an iterative planning process the intrinsic blurring induced by globalization without trying to clearly specify the roles and scope of EC as a subject of planning S&T. Since however the R&D planning machine is concretely in operation since many years, it will be a practical contribution to a new general debate on S&T policy to try to adjust the current R&D FW programme to the globalization challenges.

The priorities of the '90-94 Framework Programme can be spelled-out as:

- development and mastering of generic technologies,
- improvements of the management of material resources,
- valorization of Europe intellectual resources.

In principle, these priorities do not contradict the basic requirements for a programme conscious of the increased relevance of the globalization process. In fact:

1. a basic objective of globalization is to increase the diffuse-ability of technology and its application to new problems (in advanced as well as in developing countries). To this effect, one should ***increase the "generic" part of the technological endowment****;*
2. the basic needs of the increased population (nutrition, shelter, environment protection, etc.) require to be able to use ***more efficiently the material resources****;*
3. the challenges from globalization are such to require to ***make the most out of human ingenuity and intellectual resources***. There are, moreover, large areas in the world where the potentiality of human resources are not exploited because the low intensity of intellectual organized activities (especially S&T). These countries should be helped in the transition phase until the threshold level is reached that allows an autonomous process of valorization of their intellectual resources.

It is however necessary ***to make explicit the globalization concern*** in the declarations of priority objectives of the Framework Programme.

FAST initiatives on globalization have already pointed to the need to revisit the FW Programme taking into considerations the following five important phenomena:

- *utterance of the global world dimension,*
- *search for a new production system,*
- negative impact of the *growth,* in the allocation of material and immaterial resources, *of a purely financial logic* with respect to a more balanced allocation,
- contrasting effects of the technological development on the *cohesion of the European Community,*
- *urbanization* process and the city as a key actor of the social demand for knowl-

edge and technology.

The three priorities of the current Framework Programme listed above might therefore be mutuated also by a Programme that explicitly take into consideration the globalization challenges.

The details of the Programme require, however, to be adjusted and revised checking the compatibility of globalization with the today overall guiding principle: *to improve the international competition of the European industry*.

It should be clear, first of all, that the principle should be extended to all productive activity, be it in the primary, secondary, tertiary or quaternary sectors. However, in a co-evolution scenario, competitiveness should go together with cooperation. For globalization, one should develop special relationships between the rich and the poor nations which requires to revise the pure competition framework. How this will in practical happen?

Our proposal, as described above, is that reference be made to a multi-regional scenario. For the EC, such a region could include part of eastern Europe and the southern Mediterranean countries. With such a scenario as a reference, the above guiding principle *"of increasing the international competitiveness of the European productive sectors"* have to be enlarged. It has to *include the objectives to* ***help the marginal areas of the region to develop production capability***, taking care of the needs of a safe transition phase.

In general, to be in a position to talk about globalization issues, the EC S&T policy should spell-out *the* ***guiding principle related to the public responsibility with respect to the different society challenges*** and problems. The EC policy, up to now, has somewhat been reluctant in making explicit this guideline.

At the level of the specific actions included in the current FW Programme some can represent a base for similar actions to be adapted to a globalization scenario. Namely:

- favoring technology diffusion (the case of DG-XIII action programs),
- pushing for cooperation between enterprises (a precondition to R&D contracts),
- the case for European scientific cooperation (SCIENCE and SPES programs),
- the participation of EC to international S&T projects,
- the S&T cooperation agreements (in addition to the special case foreseen within the Lomè agreement).

The discussion on the role of EC policy for S&T with respect to globalization cannot proceed very far, unless one makes clear the general point that ***there are problems for which the Community*** (not the member countries) ***has prime responsibility***. The Community should have the prime responsibility to deal with ***problems of "Europe as a region"***. It cannot plays for such problems a role "complementary" to the member countries. There is *a need to "transfer" responsibility from the local authority to the EC*. Unless this will be obtained for the sphere of ***problems that have a European dimension***, it will be difficult for the EC to properly deal with ***problems that have a larger than European dimension***.

The proposal here, is that a revison be undertaken of the general objectives and motivations of the current R&D FW Programme to facilitate its opening to R&D projects concerned with globalization problems.

9. DEVELOPING THE CLIENT ROLE OF EC FOR GLOBALIZATION

A prerequisite to approach globalization issues is that the EC revisit its R&D policy and adapt the current FrameWork Programme as suggested in the previous sections. However, the EC should also start specific line of actions focused on the globalizations problems. We propose that the first priority should be devoted to give concreteness to the figure of the *client* for globalization issues.

We propose that the EC launches an experimental programme on globalization that will *foster multipolar initiatives,* call for creative contribution from a multiplicity of actors (both public and private), *provide a starting frame of reference* and the seeds for new initiatives.

The EC experimental programme - even if focused on the S&T contribution - will itself be multipolar.

The following types of intervention are proposed:

1. ***Play the role of the client by making use of the current R&D Framework Programme*** to incentivate as much as possible the attention to globalization issues, such as, e.g.:
    1. provide a financial premium for R&D projects that not only respond to each action lines terms of reference, but also foresee the participation of LDCs institutions or firms to the research,
    2. add a specific item on each line of action that calls for ideas and preliminary investigations on problems having a globalization dimension.
2. ***Stimulate the emergence of new clients*** by incentivating the convergence of public and private financing to set up Trusts and Foundations, each one aiming at a specific objective or approach on globalization matters, such as, e.g.:
    1. develop new products and production processes that respond to the local needs and capacity in LDCs,
    2. incentivate creativity and innovation in new products design (suited to new needs coming from globalization issues) by means of instruments such as product contests and prizes,
    3. assure the accessibility of advanced technology to design products (and related manufacturing processes) for local needs, by favouring the concept of flexible design using high technology components (both for products and processes) which could be put together to local ones (hybrid technology solutions),
    4. promote and support networks of R&D institutions.
3. ***Enlarge the client dimension*** by developing international initiatives (in cooperation with governments, GOs and NGOs) to launch the first phase (problem identification and preliminary solutions development) of S&T for major globalization issues, such as, e.g.:
    1. attack environmental global issues,
    2. exploit global commons
    3. develop low cost, socially acceptable shelter technology for massive inhurbated area,
    4. experiment marginal agriculture technologies,

5. develop a multimedia new encyclopaedia of technology and know how's.

4. ***Act as a client in search of good ideas for ill defined problems***, by setting up an "open counter" initiative to incentivate with financing any kind of unsolicited proposals that can contribute to develop a portfolio of ideas and globalization issues.

Appendix

A grid to select a list of priority S&T issues

We propose a four levels grids to classify the challenges and the related S&T policies:

- according to the class of the challenge
  - **V** = vertical / **H** = horizontal
- according to the spatial dimension of the challenge / problem
  - **L** = local / **R** = regional / **U** = universal / **G** = global
- according to the direction of the action-taking
  - **P** = top-down planned R&D / **E** = bottom-up exploratory R&D
  - which could be combined with the different phases of the process such as **d** = problem definition / **s** = solution design / **a** = solution assessment
- according to the degree of innovation change aimed at
  - **T** = tactical change (configurational design) / **S** = strategical change (systemic design) / **V** = value change (structural design)

What follows is an example of how to uses the proposed grid with no presumption for completeness or priority settings, starting by separating vertical and horizontal challenges:

- vertical challenges
  - (V) environment protection
    * (VR) Monitoring Natural Systems At Regional Level
    * (VG) Global Earth Monitoring
  - (V) better management of the territory
    * (VR) Developing regional infrastructure
  - (V) Better exploitation of the natural resources for a sustainable world
    * (VG) Exploitation of biological marine resources
  - (V) Responding to the shelter needs
    * (VU) S&T application to the shelter problem
- horizontal challenges
  - (H) Learning to master complexity
    * (HL)Helping public operator to deal with complexity
    * (HR) Developing a Commonwealth of Sciences for the enlarged European region
    * (HU)Developing systemic approach to problem definition
    * (HG) Globalization of Science and globalization issues
  - (H) Putting technology to work
    * (HL) Promoting local entrepreneurial activity

The first selection of themes should then lead to identify more specific problems at different "dimensional levels.

Sample List Of R&D Projects Objectives

(V) Environment protection

This broad challenge cover all the different levels (local, regional, global) which show strong interdependencies from one to the other level. Public and private actors are involved in responding to the challenges as well as the individuals. In trying to translate the challenges into problems a basic concern is the difficulty to "understand" the signals that the environment (as a complex system) send out. Having circumscribed somewhat the problematique, we are faced with different dimension of the problems at regional (R) and global (G) level, such as:

(VR) Monitoring Natural Systems At Regional Level

- development of a "block model" for the global natural system subdivided into subsystems characterized by object and scope so to select the "regional subsystems" to be subject of monitoring, (**Ed / S**)
- develop detailed models of regional subsystem (water basins, regional seas, quality of air) and the related monitoring to feed the models to get information of practical use (action oriented),(**Ps / T**)
- set up large field experiments to improve knowledge on cause-effects relationship related to human activity.(**Ea / V**)

(VG) Global Earth Monitoring

- develop effective earth monitoring tools and processes, (**Ea / T**)
- develop a world scale model to process the monitoring data in order to produce information of relevance for decision-makers, (**Pd / S**)
- develop regional, local monitoring systems that can be integrated to the global earth monitoring one, to produce data relevant for local systems management, (**Pd / S**)
- develop regional/local models to elaborate the monitoring data to obtain information useful for regional/local interventions (e.g. to avoid flooding, to adapt the type of agrocultures to prospected weather changes). (**Ps / T**)

(V) Better management of the territory

One important challenge is related to the way human activities are distributed on the territory, which lead on one side to saturation of space (inhurbation trends) and on the other to the abandonment of entire regions with its consequent decay. Many of the problems we are faced will be eased with a more equilibrated use of the territory. A prerequisite to that is a more homogeneous distribution of different types of infrastructures. We might here underline the importance of the transport and communications infrastructure.

Also in this case the challenge has many dimensions. However, it emerges from globalization - i.e. from increased interdependencies - the need to look more and more at the infrastructures as regional, continental or global networks. An example of programme covering the regional (R) aspect, is:

(VR) Developing regional infrastructure

- support the development of a portfolio of projects for "European networks" of infrastructure based on the use of advanced technologies (fast trains, computerized control systems for air/roads/rails, etc.), (**Ed / S**)
- set up models that represent regional infrastructure networks to simulate emerging bottlenecks and the responsible flow of traffic, (**Pd / T**)
- launch regional experimentation on-the-field for new technologies applied to infrastructure projects, (**Ps / T**)
- support the development of a portfolio of infrastructure projects considered as integrated networks for less developed regions, (**Ed / S**)
- set up proper institutions that can deal with the regional problems (such as the ones proposed by the European Round Table: an European Infrastructure Institute to monitor the situation and to propose initiatives, and a European Agency with the power to implement projects). (**Ed / S**)

(V) Better exploitation of natural resources for a sustainable world

Interlinked with the environmental protection issue is our inefficiency on one side and aggressivity on the other in dealing with the exploitation of natural resources. One problem that emerge to the attention of the globalization issue is that of the exploitation of the **commons** at all levels, such as:

(VG) Exploitation of biological marine resources

- global marine water monitoring and evaluation systems (water quality, biological species, etc.), (**Pd / T**)
- development of a portfolio of ideas for global scale technologies, (**Ed/V**)

- development of fishing technologies which take care of maintaining fish population levels, (**Pd / S**)
- development of coastal waters aquaculture processes integrable in the global resource management system, (**Ps / S**)
- development of a global monitoring system of fishery activity to make possible to implement patrolling at global level. (**Ea / T**)

(V) Responding to the shelter needs

The shelter challenge faces the less developed regions of the world as well as the richer ones. The peculiarities of the problems and the ability to tackle them change from one case to the other. However, not withstanding the differences, there are common characteristics of the challenge. It might therefore be important to develop action programmes that call for a cooperative approach in at least part of the problem solving process. The"universality" (U) aspect of the shelter challenge are underlined as:

(VU) S&T application to the shelter problem

- research on system approach to highly dense urban systems, (**Ed / S**)
- simulation programmes to serve as a base tools to specify the terms of reference for problem-solving in sheltering in dense urban areas for very different "environmental" and social conditions, (**Pd / T**)
- development of a base "multipurpose components" of high technology integrable (hybridable) with quite different building technologies. (**Es / S**)

(H) Learning to master complexity

The evident increasing "crisis" in decision-making in many instances is due to the "emergent' complexity and non-linearity of the system on which action should be taken. Social system are always complex and non-linear. However such complexity might not necessarily be apparent to the decision-makers if the non-linear feed-backs (externalities) of the human action on the system are small, or if the system is very stable and far from bifurcations. The emergent globalization is an indication of reaching conditions where this is no more valid. Therefore it is very important for decision makers at all their levels of action to learn how to better deal with complexity. We can underline different instances (local, regional, universal, global) where improvement in the ability to deal with complexity can be sought for:

(HL) Helping public operators to deal with complexity

- analysis of cases of failed intervention on "public" complex system to learn from errors, (**Pa / T**)
- development of a methodology to "instrument" public systems (e.g. urban systems) to collect and translate data in terms useful for decision makers, (**Ed / S**)
- development of a portfolio of technology-push ideas on potential actions on typical public systems, (**Ed / V**)
- simulating the dynamic system behaviour of specific cases of interest to support (evaluate and assess) specific designs of intervention, (**Pa / T**)
- development of a methodology of "trials and errors" (scientific method) approach to act on complex system by extending the concept of experimentation (from laboratory to the field), by monitoring actual field experiments on selected cases in order to assess effects of interventions. (**Ea / T**)

(HR) Developing a Commonwealth of Sciences for the Enlarged Europe

- promote the creation of consortia between existing universities to create new ones or to help existing ones to increase their research activities, (**Ps / S**)
- promote vocational training both by classical methods (schools) and new ones (using new information and communication technologies), (**Es / T**)
- promote the creation of technological centres of information, central scientific libraries and others means to facilitate the access to the scientific and technological information, (**Ps / S**)
- promote the intervention of private/ public foundations to support the growth of sciences

in the less developed countries, (**Es / S**)

- promote and support the creation of international institutes for base and applied sciences located in the less developed area of the region and a scheme to help the starting of efficient research activities with the cooperation of existing research institutions, (**Ps / S**)
- enlarge the COMETT and ERASMUS Programme activity and extend it to the Eastern Europe and the souther Mediterranean countries. (**Ps / T**)

(HU)Developing systemic approach to problem definition

- general research on applied system dynamics, (**Ed / V**)
- simulation and monitoring of existing natural and/or social systems (learning from the approach of nature in problem solving), (**Pa / T**)
- in field experimentations of "what-if" kind, in a variety of public systems to support heuristic approaches to problem solving, (**Es / S**)
- simulation and experimentation of intervention to control systems in saturation conditions, (**Es / T**)
- development of educational and training tools for decision-makers on the practical approach (new "wisdom") to intervene on non-linear systems. (**Ed / V**)

(HG) Globalization of Science and globalization issues

- In depth analysis of the clustering mechanisms in basic and applied sciences around the world. Understanding of direct or indirect role of actors (individuals and institutions) in organizing sciences. Testing of the sensitivity to change patterns, by launching a series of grants for individual scientists willing to change their research agenda on new themes more related to globalization issues. (**Ed /V**)
- In depth analysis of the state of science to recognize and underline the clustering of scientists on themes closer to globalization. Call for bids for analysis performed by scientists themselves to show how and why the existing research agendas is close to some of the globalization issues and what could be the ways to make it even closer. (**Es / S**)
- Call for bids for research programmes on sciences applied to globalization issues to be performed by large networks of scientists (including North and South countries). (**Ps/ T**)
- Extension of the SCIENCE program (which aims at increasing cooperation between European scientists) to eastern Europe and to LDC's, and greatly increase the financial resources to accelerate reshuffling effects on the spatial patterns of cooperation. (**Ps/S**)

(H) Putting Technology Transfer to work

One very import trump card to deal with globalization is to exploit the potentialities of S&T. Such cards however are not uniformly distributed in the the different regions of the world. One important objective will therefore be to help the operators in less developed countries to better organize to use the S&T potentialities. This however is a problem not limited to LDC's. One will have a lot to gain also in advanced countries by enlarging the access to S&T for problem solving. Here we select an idea having a local (but also universal) span:

(HL) Promoting local entrepreneurial activity

- prize contests for new products fitted to specific local needs (agricultural machinery, renewable energy sources, improving productivity of services, etc.), (**Es/S**)
- promoting industrial design schools and centres, (**Ps / T**)
- promote infrastructure and services for local entrepreneurial activity, ((**Ps / T**)
- develop a data base on generic components and production-processing elements available world-wide. Develop procedures and tools on how to use the data banks at local level, (**Ps / T**)
- develop training material to show potentiality of new products creation by assembling high technology generic components with local technology and material and diffuse it (open-school via satellite, etc.), (**Pd** / S)
- incentivate joint-ventures between firms operating in developed areas and old or new firms in local underdeveloped regions. Support, as well, "triangular" joint ventures including firms from emerging countries with experience closer to LDC and having learned how to integrate generic and local technology. (**Es / S**)