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System analysis and S&T policy needs

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Introduction

'The basic justification for rejecting traditional precepts of rationality, planning, and balance is somewhat different for the three approaches here examined. For Lindblom [in policy making] it is the *complexity*, i.e. man's inability to *comprehend* the present inter-relatedness and future repercussions of certain social processes and decisions, as well as imperfect knowledge and *value conflicts*. For Klein and Meckling [in R&D] it is almost entirely *future uncertainty*, i.e. man's inability to *foresee* the shape of technological breakthroughs, or the desirability of letting oneself be guided by these breakthroughs if and when they occur, instead of following a predetermined sequence. For Hirschmann [in economic development] it is the difficulty of mobilizing potentially available resources and decision-making activity itself; the *inadequacy of incentives* to problem solving, or, conversely, the need for 'inducement' to decision making.'

(from A.O. Hirschmann and C.E. Lindblom, *Economic Development, Research and Development, Policy Making: Some Converging Views, in Behavioral Science*, vol. 7(1962), pp.211-22)

Globalization stands for an increasingly complex and more interactive world, which will be far from becoming, in the next 20 years, an *homogeneous global village*.

The increasing importance of globality is just one indicator of the increased interdependence in all sectors involving local, regional, world-wide dimensions.

The increased complexity of human affairs undermines our capacity to address and solve the problems we are faced with, notwithstanding the S&T progress. A general preoccupation is the increasing gap between problems and solutions, no matter whether we are talking of the North or of the South of the planet although there are proportional larger difficulties in less developed countries.

Feeding, sheltering, increasing the quality of life of some 8 billions people are short ways to indicate an intricate, interconnected large variety of problems to be solved. Some of them are new, others are old. These latter problems, however, are more difficult to solve than in the past, because of the level of 'saturation' (take, e.g., the population density in urban area) of the system where such problems appears.

Globalization might change our way to see the world. It might push us to revise our understanding of political-market-social liaisons and reactions. It might challenge the rational behaviour of operators because of new patterns emerging from the increasing non-linear dynamics of the global system.

Indeed non linearities have always been intrinsic in so complex systems. However, patterns of behaviors have emerged and stabilized in the past to which we are used and which guide our expectations and 'rational' behaviour. Globalization trends might now result in new patterns, unexpected or to which we are not instrumented to react. As an example, the globalization of information increases the tendencies of local 'diversities' to fight for their survival while in the mean time urging for an homogenization of life quality and expectations. The vision in real time of what happens in distant areas might increase our sense of human solidarity or, to the contrary, increase the tendency to defend our better way of life or our presumed superiorities. From the interactions of all these elements it is difficult to forecast the

behavioral patterns.

As citizens of the 'global' world, we might therefore have to revise a lot of our certainties.

The Planning challenge

However, these potential and debatable impacts of globalization - as important as they are - are not the primary focus of our concern here. Our focus instead will be on those problems - or, better, challenges - that we perceive emerging, or feel already existing, and against which we cannot simply stand with a 'wait and see' attitude. Can we *plan actions* to avoid that today challenges will develop into tomorrow catastrophes of global dimensions? The non-linearity of the systems makes it difficult to plan successfully and it might well be that at the end a *laissez faire* approach will result in a better development. It might well be that *collective patterns* (changed as they might be due to the increased interdependence) will *spontaneously* develop in a way that reassure us (similar to the *invisible hand* postulated in classical economy to emerge from individualistic, egoistic, short-term sighted behavior of an aggregate of economic operators). But, who can tell?

In any case, some of the challenges we face are such that we cannot simply stand without trying to do something. However, *we cannot but feel, together with a sense of urgency, the difficulty of the task.* What methodology can support us even simply in trying to *pass from the perception of challenges to the definitions of problems* that derive from them?

Our specific task here is to assess what S&T may contribute to this process. The past successes of *planning* the application of S&T 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 determined decision making process.

We know that no simple answer can be given to the naive questions put by the layman: *why is it that we can organize to go to the moon and not be able to distribute the agricultural surplus to starving people? How is it that we can plan the use of mostly uncertain state of science to prepare for a space-war (and be successful in developing the dreamed-of arm system), while we can not transfer the advances in medical care to reduce infant mortality in the poor part of the world?*¹

When comparing *civilian* with respect to *military* R&D programmes, a first difference that emerges is the different contexts of the decision making. In the military context, an ability to translate scenarios into challenges and, then, into specific terms of reference of problems to be addressed exists. Such skill is not reproducible in the democratic civilian context especially to cope with global issues, due to the lack of proper international institutions..

¹That no simple answer can be given to such questions can be hinted at by the fate of ambitious R&D programmes aimed at *civilian objectives*, such as the USA RANN (Research Applied to National Needs), or EUREKA, or the Nato CCMS (Committee on Challenges to Modern Society), at least if one compares results of actual development to the originally stated objectives.

In order to answer the question '*can we plan actions to take advantages of S&T advancements to tackle globalization priority challenges*' we need therefore **to focus on the definition of the proper methodology**. Our report mainly address this issue.

To perform the task we will have to be supported by the reference to specific issues and problems. However in the main we will adopt a general approach, leaving to the responsibility of other parallel works of the *Global Perspective 2010* team to deal more specifically with sectoral issues.

Before entering into the 'concrete' phase of trying to describe specific *physical* problems and to pose the question of what S&T can do for them (i.e. developing a perspective for a methodology of actions) we have to take a broader view. First, we should ask ***what makes globalization issues so difficult to approach***, and if such difficulties have common roots or common features.

The scale and interdependence of the globalization issues

The problems related to the globalization process - in a more and more dense and unbalanced world - are impressive first of all for their *scale*. The first problem therefore is that of the availability of resources to deal with such a scale. Secondly, they are impressive for the ***systemic interdependence of the variables*** characterizing each problem.

Let us start with the problem of the limited *resources* - compared to the scale of the issues - to assure a 'sustainable development' (that will represent not only a reduction of 'spatial and social' dis-equilibria but an overall progress). We can represent the variety of needed resources in a multidimensional *space*. Part of the coordinates represent the physical (hard) environment and another part of this space the virtual (soft) human environment (including our ability to respond to the globalization challenges). According to this representation the basic question become: ***Do we live in a finite 'space', and are we close to space saturation every where? If so, is it possible to create more 'space' or to better use the space already occupied?***

The general reaction to the globalization challenges should be ***first*** of all *to look for resources* (physical and human spaces) that exist but are *wasted by inefficient use or are not used at all*, and hope that there are slacks available to meet the sustainable development objective.

The ***second*** line of search should be that of designing a more '*just*' allocation of *resources* in order to reduce the system local *saturation*. However, here one should proceed very carefully, since history has indicated that often the tentative to reduce unbalances in resources allocation is accompanied by an increase in wastes and non used slacks and by a reduction in the overall speed of progressive change.

The ***third*** line of search should deal with the question of *whether or not new resources (additional spaces) can be created*. The importance of this third line relates to the fact that so many of the objectives that human society poses are bound to be incompatible in a 'closed' world (e.g., the case of environment safeguard and energy consumption). The only possibility to make them compatible is to enlarge the 'limits' of the system, that is to create additional 'space'. Therefore, unless we are confident that resources can be created the probability of success to respond to the globalization challenges is scant.

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: let us analyze the *physical problems* that emerge as priority ones and look for *physical solutions*. So, the *waste of resources* can be detected and better processes developed to reduce them. The search for *more 'just' allocations* of resources use (such as the physical urban space) might lead to new technological solutions to respond to the needs (e.g. public transportation instead of private mode of transport) to reduce the saturation of urban spaces). The preoccupation to *create new resources* can point to radical new technologies (e.g. the nuclear fusion approach for energy production).

If we jump right away on this concrete approach - list a set of priority issues and find solutions - we risk however to be constrained within the too narrow bounds of *technical fixes*. They might be available for some of the globalization problems (such as a more efficient uses of physical resources). However, without excluding that for certain specific cases there might be some *ready to apply* technical fixes, in general - because of complexity, non-linearities and uncertainties (at all levels, from ends to means) - the effect of S&T in helping to respond to the challenges will be visible only at the end of a quite complex process and be subject only to an *a posteriori* rationalization.

When technical fixes are not available, when their application delude us or produce unexpected undesirable secondary effects, or finally when the S&T approach seems to be too erratic and difficult to plan, we should question the approach of considering the problem as already on a physical level.

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. Cannot instead each specific problem be shifted to a different 'dimension', where it will be more easy to approach it? In fact, if the problem is one that appear in a 'subsystem' or 'component' of a system in a state of saturation, there might be few chances to solve it without addressing the problem of changing the entire system (thus going far from saturation).² Correspondingly, the problem of the contribution of S&T has to be approached with a broader view than simply looking for technical solution for specific problems.

A first important criteria in looking for S&T contribution to globalization is therefore that ***S&T should be looked-at with priority to contribute to the task of producing new resources, no matter whether we concentrate the attention on 'hard' (e.g. new non-air polluting energy sources) or 'soft' ones (e.g. a more readily accessible technologies apt to help developing local responses to problems).***

Revisiting popular wisdom in a globalization context.

²This is why we have already underlined that if lack of 'spaces' is a characteristics of globalization issues, than the priority objectives is to create more 'spaces' before tackling specific problems.

The above remarks remember of two old says that represent the popular wisdom in problem solving:

- teach a poor hungry man to fish: you will feed him for life and not just for one day;
- a well posed problem is already half solved.

In effect, the scale of the globalization problems suggests the need to *develop virtuous circle of wealth generation* (resources), while the interdependence suggest the need to disentangle the situations (breaking down, if needed, the system structure) *to be able* to go to the core of the problem to be solved.

However, the pervading patterns of globalization make it difficult to follow the two old wisdom recipes. Take the case of the South of the World. The related problems cannot be met on the longer term unless ways are found to develop local virtuous circle of wealth generation. However, what is the best path to be followed? Should LDCs imitate the long and painful (but having lead to success) path from agriculture, to industrialization, to post-industrial society of the North countries? Is not it possible to shorten such lengthy process and to leapfrog some stages of development? Or - even more important - is globalization, with all its interdependence, actually impeding LDCs to follow that type of trajectory?

'Teaching a hungry man to fish' is still a valid and needed recipe, but we don't know what is the 'proper way of fishing' in the 'globalized waters'.

If we pass now to the second part of the popular wisdom recipe, we cannot but emphasize that globalization requires more than ever to dedicate efforts to define the terms of the problem before trying to solve it. However it is the globalization itself that makes this task very difficult. In fact, problem definition requires - after having duly considered interdependence - to be able to cut down some of these interdependence (separation of variables) to make the problem solvable.

The proper example here is that of the effect of globalization in blurring the *dimension* of any given problem: can we still tell when a problem is *local, regional* or *international*? A problem pertaining to a class of problems up to now considered as *local*, might - because of globalization - have shifted to a *broader dimension*. Viceversa, we might be tempted to shift to a broader scale a problem that still pertain to a narrower dimension, because of the increased complexity in problem solving.

These side-steps reflections serve to re-emphasize the above remarks that:

- there are no simple fixes (technical or not) to respond to globalization challenges;
- one of the most relevant part of the difficulty lies in the ability to reflect on the problem (to pass from perception of the challenge to the definition of the problem) before organizing to solve it.

We have therefore to insist on the methodological issue.

Non linear problem solving: mixing policy, organizational, S&T uncertainties.

If we rightly have to enlarge the scope of S&T (from that of looking for technical fixes for well defined problems) and to broaden the point of view to that of a global system, then an important consequence utters. The non-linearities of the global system cannot be neglected. From the point of view of trying to define *what* are the

globalization challenges and to specify the related problems and priority issues, we have to take into account the '*physical*' *non-linearities* (the interdependence between different physical subsystems, such as energy, environment, medical care, etc.). However, if we then pass to the task of *how* we organize to respond to the challenges, then we have to take into consideration more '*soft*' *non-linearities*, as those between different social-organizational subsystems (such as political representations, public bureaucracies, international organizations, S&T actors, etc.).

In other words, we cannot escape from the difficult task of considering *the non linearities in problem solving*.

A first important consideration emerge here: the more one departs from technical fixes, and enlarges the task of S&T, *the less S&T can be left to the 'expert'*, and the less a linear approach in problem solving³ is possible. A linearized problem solving approach is the more difficult to be applied in presence of great uncertainties, as in the case of globalization issues. Uncertainties extend to all levels, from socio-political, to institutional, to physical. The task to sort out the S&T own uncertainties cannot be left to 'experts', since they intermingle with other uncertainties and enter into the process to define the objectives, to allocate resources, to look for alternative routes.

The result will certainly be a lengthening of the decision-making process, at least of the phase between the perception of the challenge and its translation into specific solvable problems. This might prove necessary not only to assure *effectiveness* (the selection of the right problem), but also *efficiency* in actually organizing the response to solve the problem.⁴

The decision-making loop: the blurring of actors role and responsibility

By following the line of reacting to the impressive *scale* of globalization issues, taken as *physically defined* problems, we have thus been pushed to be concerned with its second impressive characteristic, that is *complexities, interdependence* (everything mixing with everything else).

The globalization process - because it exalts system interdependence and non-linearities - is first of all a challenge on the way we tackle problem-solving, no matter which of the related issues utter to our attention.

The higher the interdependence and non-linearities, the more difficult it is to follow the 'rational' approach of optimization in a linear subdivision of tasks. *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*. Therefore, even if eventually the problems to be dealt with are physical, we should look from a broader angle, before organizing the proper physical response.

³Some one defines the issues and sets the objectives, some one allocates resources and someone else uses his expertise to develop a solution.

⁴It might be interesting to recall here the debate on the management approach that seems to characterize Japan enterprises. The Japan competitive advantage on USA and Europe, according to many observers, seems to be riconducibile to a different management approach which dedicate a much longer time to debate the problem with all potentially involved actors, before passing to the solution phase.

The scopes, the roles, the divisions of competences of the hierarchical levels characterizing the organization of our society (the political, the governing, the physical acting levels) have to be revised no matter how great the political difficulties.

The linearized problem-solving process can only be the starting point of a process which will proceed in a very unbalanced way: with 'invasion' of competence from one level to the other, followed by retreats; in concentrating resources on a solution path, followed by the shifting of interest and priority to an alternative one; by fixing targets to be changed later on as soon as preliminary uncertain results become available.

The need to learn how to approach problem-solving.

A further consideration that emerges at this stage of the reasoning is that not only one should look with priority to certain ways to approach the specific globalization problems (looking for more radical solutions that enlarge the 'space', that produce more resources), but also that efforts should be devoted to '*learn to learn*' how we should deal with the globalization problematique.

It is easy to agree on the importance of non-linearities and interdependence in globality issues. However, this does not imply that we know how to take this into account. Actually, all our experiences in problem solving is based on assuming that *variables can be separated*, in reducing complexity by breaking it down in simpler issues (whose interdependence can be assumed assume as negligible in the first instance).

We need therefore to include the development of a problem-solving process that fit the complexities, interdependence of globalization (how to deal with saturated non-linear systems) among the globalization challenges.

In this adapted problem-solving process, S&T cannot be considered a tool to be left to the specialist of the 'physical' level of the problem solving process. The *means* of S&T with the related 'vision of the future potential world', should also be used by higher political and executive levels to assure that the system follow a the 'desired' direction (ready to change or adjust the definition of the 'desired' direction).⁵ This consideration has profound implications in the definition of S&T policies to respond to globalization challenges.

The three levels concerned with S&T policy-making.

The problem to react to the globalization challenges by developing proper S&T policies and action programs should concern all the levels of the societal system.

For the sake of clarity, one can start with a simplified division of the system in *three levels*: the political, the governing, the operating one.

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 other.* Let us give some examples. At political

⁵Because of complexities and non-linearities it is on one side very difficult to establish which is the right direction to be followed to obtain the desired results. On the other side one is not sure of what are the results to be desired, because they also depend from the interdependence between different inter- and intra-society sectors.

level, one might look for technical fixes and pretend that S&T has no uncertainty in providing supporting evidence and in defining the course to be followed; or, on the reverse, one might look for changes to meet a new scenario and, in this case, reject S&T certainty, should it makes such changes improbable. To tackle the problems defined by the analysis of the challenges, one must appeal to the tools and the resources available. Programme feedbacks may confirm or not the correctness of the choice of priorities, and, at the same time, outline the need to develop better tools and means.

The barriers to respond to the globalization challenge.

It is hard to talk of decision-making in terms of dealing with non-linearities and intertwining of feedbacks in a culture that appreciate the approach of Alexander the Great when confronted with the Gordian knot.

However, if we follow a linearized approach, the non-linearities, the feedbacks, the complexity of the problem will appear in terms of *barriers* to pass from one phase to the next of the *solving process*.

The first barriers utter at the very first phase of problem definition in terms of lack of consensus on what the real issues at stake are. The difficulty to reach consensus is intrinsic in the complexity of the problem, in the uncertainties on data, in the too quick identification of problems (by looking at potential solutions) or viceversa in the lack of support on a broad enough portfolio of ideas on potential solutions that gives us confidence and determination to proceed. Building consensus is a democratic process that interest all concerned partners; in the case of globalization issues this often means the whole world society. The difficulties in the process demonstrates our illiteracy at political level in dealing with complexity, and the problem becomes even worst when the international dimension is added.

The fundamental issue related to such barriers is therefore the following: can we develop a *design process* which is at the same time a *democratic* one?

The second type of barriers utters when passing at the phase of solving a problem on which the consensus is finally achieved. One important barrier is related to resource allocation, and, even before, to the identification of the *client* that has the right to plan for problem solving and the duty to provide the needed resources. Here, 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. Or, viceversa, barriers to transfer resources (social solidarity) from higher to lower levels (or from rich regions to poor ones) if the problem is local but requires resources which are not locally available. This type of barriers is also amenable to *illiteracy* in dealing with complexity. In fact, barriers could be overcome if one was capable to 'translate' solidarity in terms of self-interest, by recognizing the longer term faraway feedbacks of unsolved local problems (e.g., the problem for EC of the immigrants from North Africa).

Even if, having decided where the resources come from, one has succeeded in passing to the problem-solving phase, there are barriers that utter at that phase. Some barriers have to do with the difficulty of planning to meet specified design objectives under condition of high S&T uncertainty. The success of a plan depends upon *the*

specific top-down planned actions, but also on the richness of the S&T context, that is on the portfolio of scientific and technical ideas which result from bottom-up initiatives.

Barriers come from the resistance of S&T communities to select general research agendas that covers fields of interest for the top-down planned actions. Such barriers however might be the result of a former failure to respond to decision-making feedbacks, such as the failure to create *institutional clients* or promotional initiatives supporting the bottom-up research initiatives that shift to areas of potential interest for future (globalization) issues. Again, a better understanding of non-linearity and complexity in S&T planning could reduce these barriers.

It is interesting to note that 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. These signals should be rightly interpreted by all the society levels involved in decision-making.

Actors' role, scope of responsibility, methodology.

The difficulties created by loopings and feedbacks, by barriers and the blurring of roles and responsibilities should not however stop us from proceeding to tackle the globalization issues. Because of the problem/solving-process interaction, it is important to start to focus on actors, scope, responsibility, methodology.

We start here from a tentative definition of the principal roles and responsibilities of each level:

- the **political level** should identify the globalization issues (by analyzing challenges) and *organize the societal consensus* to deal with them. A first challenge is to find out how to succeed in organizing such a consensus. One is forced to note that the mechanisms at work to that effect are unknown or difficult to master (we have another instance of challenges where the process uncertainties add to the end-product uncertainties). In any case, consensus building may not be made in the abstract, but it should already be able to account for the actual possibility to approach with success the different issues. This requires to directly enter the designing phase of the problem-solving while still trying to agree on issues and objectives. As a consequence, we may say that, at the political level, the design process has to be developed as a 'meta' process (*designing the design*). At the end, the outcome will (considering all looping and feedbacks) be the definition of values and objectives, priorities, and the definition of alternative routes to be in parallel explored.
- the **government level** should organize the response to the identified priorities by allocating resources to specific '*direct*' (or '*vertical*') programs of action (calling for the intervention of the interested operators). However it should also be concerned with the 'learning to learn' process (needed to approach the globalization issues) both by predisposing a frame (norms, regulations, incentives) inducing the 'private' operators to act 'spontaneously' (i.e. in syntony with the recognized needs to respond to the globalization issues) and by allocating resources to '*indirect*' (or '*horizontal*') programs of action aiming, for example, to modify the general accessibility of S&T endowment, the level of vocational training, etc.;

- the *operative level*, and more specifically the S&T sub-level, should respond to the call for intervention on specific ('direct' and 'indirect') programmes by organizing a planned top-down response. Furthermore, it should also contribute to improve higher level decisions on issues and responses. by feeding backs ideas and proposals

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. The protocols for action should also take in due consideration the further complication implied by the fact that the spatial hierarchization of actors (local, national, international) is not necessarily the best suited to match the globalization issues. Therefore, they should propose the necessary institutional changes. The existing international governmental organizations have built-in limits (sovereignty and fund raising methods) which might not be adequate to deal with real global problems. Other non-governmental organization might find difficult to push their goodwillness beyond the simple identification of issues and problems.

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

- 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 not only monitor trends but that is also able to alert on side effects of non-linearities such as the sudden utterance in importance of dormant issues, the potential alternative outcomes from actions, the need to adjourn objectives along with the progress of S&T⁶ ;
 - take the consequence of feedbacks in the problem solving process and call for a *meta-design* responsibility at political level which assure at least the coherence between ends and means, between the vision of the world and the proposed routes to respond to the consequent issues;
- 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 (including agreements, pacts and treaties) for *new institutions to be created when needed*;

⁶To give some examples. The exploitation of *global commons* such as sea nodules might be a dormant issue, that could re-emerge (because of new technologies), in a time scale much shorter than the one needed to organize an international agreement. *Good actions* to improve quality of life in poor regions of the world (such as developing conventional energy resources) might have negative secondary effects of a scale proportional to the success of the intervention. Scientific break-through are difficult to evaluate in their potentiality and there is both the risk to over- and under- estimate them. Here, the ability to deal with uncertainties (political as well as S&T) is relevant.

- the general frame for action in term of norms, regulations, incentives to induce 'attitudinal' changes in operators' behaviour that favour the dealing with the globalization issues;
- 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 ('directly' as well as 'indirectly' by predisposing the field for future more direct actions on specific 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 need to specify the S&T clients.

The success of any policy for actions related to S&T will depend on the relationship between S&T actors and other society actors. We are here therefore interested in how to improve such relationship. In general, and this apply also to the globalization preoccupations, one way to look at such relationship is to consider S&T as an *offer* (of ideas, of services, of physical and human resources) and to ask what is the corresponding *demand* to face the S&T offer. The question therefore regards how to improve the relationship between S&T demand and offer. It would help very much the process if we succeeded in better specifying who are the clients for S&T.

The effects of the non-linearity of the decision-making process (the blurring of the division of responsibilities, the needs to directly access to S&T at each level) make more difficult a clear identification of clients. We need to extend the search for clients at the different levels. One important contribution to the protocols will be to identify the client role of the different levels and *specify what different R&D programmes respond to the different clients*:

- the *political level*, for programmes that call for bids of 'conceptual' design and intervention to feed the 'meta-design' process;
- the *government level* for programmes that aim to make the S&T endowment more accessible (i.e. increase its 'generic' potentiality, and then facilitating technology transfer, increasing the adaptability and the integrability of technology to fit the different stage of the technological regime in different area of the world, etc.), 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.

The clear singling-out of clients (having the power to 'buy') representing the 'demand' for globalization related S&T, will act also as a powerful *stimulation of bottom-up creativity* of S&T operators, who will respond to the potential S&T demand by modifying their priorities of research.

The protocols for actions should also underline ***the need to create new R&D institutions*** that should receive patronage from the different hierarchical levels, such as, example giving:

- monitoring and alerting institutes on globalization issues with a patronage at political level;
- networks of international research institutes on technology transfer with patronage from governments and IGOs.

Developing the design process for globalization.

We can now go back to the initial concern: *can we plan actions to call in S&T with all its potentialities to respond to the globalization challenges?*

Talking about planning means that we have already overcome the initial difficult phase of passing from globalization challenge to problem definition and to solution identification. Our concern should then be more general and the corresponding question be: can we *design a response?*

The above discussion points to a pre-conditional methodological issue. The problematique that we have introduced is well known to scholars of the design process. However, usually they refer to the problematique of the *individual* designer facing difficult design issues to respond to *individual clients*. Instead, we are dealing with globalization issues with what is essentially a **democratic design process** involving *social groups to play the roles of client and designers*.

The design process is a sequence of *divergent* and *convergent* phases. First, a convergent phase of problem perception occurs. Afterwards a divergent phase that look at a variety of possible problems of potential solutions takes place. Finally, a second convergent phase, dealing with the terms of reference of the problem to be solved, develops.⁷

In general one can consider the design process as a sequence of generation of ideas and selection of the best fitted ones following a path that leads to the design objective. The solution path is followed very quickly if the potentially interesting ideas already exist and the selection can take place without delay. Technical fixes may represent such a case. However this seldom happens. New ideas have to be generated to assure selection of the best fitted ones to meet the objective.

What kind of general suggestions can we get from this general description of the design process, when we apply it to a *democratic design process?*

First, we should stress the need to have the participation of all the society sectors to the design game. We can distinguish between the 'meta-design' and the actual one to get the message through. 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.

⁷The designer, after having accepted the problem specifications, pass through a highly divergent phase of search for alternative solutions that not necessarily are strictly bounded to the accepted specification so to assure the possibility to come to an optimal (or good enough) solutions) that might require a revision of the early problem's terms of reference). The selected solutions is a global frame of reference that include several uncertainty areas (at sub-systems or components level) for each of which the same divergent/convergent process might have to be followed.

We enter here directly into the S&T sphere. The consequence 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 this respect, it is not necessary to assume that the best choice of issues is done. It is sufficient that the chosen issues lead to generation of ideas in the good directions.

Who should take initiatives? At all levels: national, European, international level. Nevertheless, it is important to underline that there is a very important 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 division among actors characterizing the globalization case. Globality mixes the cards. New roles have to be designed, new method in decision-making to be developed.

In particular the EC has the following opportunities:

- to stimulate European Community R&D counting on a strong leverage effects due to EC centrality,
- to define new issues, even the more uncertain ones, profiting of the EC general discussion mechanism.

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

In summary

To *summarize*, these introductory remarks, we should note that by rejecting the approach to focus right away on specific problems (hoping for technical fixes or planning direct technical solving approach), we have been involved in a loop that apparently brings us quite far from the concreteness of the problems to be dealt with.

However, entering in the problem/process loop, and therefore *accepting the loop logic to shift attention, at the beginning, from problem to problem-solving process is a prerequisite to be better able to deal with the globalization issues*, and at the end be back at the problem side of the loop.

For our scope - to look for the role of S&T in dealing with the globalization issues - it might seem quite a long detour to discuss of the higher levels than the one where lays the physicality of the problems. At the end, however, we are confident to be back to a concrete approach, better equipped to answer questions related to the S&T role.

The Report organization.

The present report is aimed at showing how S&T participate to the efforts to organize a response to the globalization challenges at all the three levels above indicated.

The *first part* is dedicated to tracing the trajectories of the emergence of the globalization issues and the interrelated S&T aspects. We cannot limit our analysis to examine the physicality of globalization. We should see how globalization appears at higher 'softer' levels: *what globalization means in the geo-political 'space'; how it affects existing actors or creates new 'global' ones, and its impact on the ability to 'govern' the globality issues. Finally, S&T itself is undergoing some sort of globalization which might or not enhance our ability to use S&T as a tool for globalization issues.*

The analysis confirms that the path to globalization not only asks for the solution of new 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 tendencies to world scale homogenization against multipolarity and to the valorization of local diversities; ii) the difficulty to make a satisfactory compromise between the thrust in greater efficiency and in greater equity in economic development; iii) the need to deal, in the globalization trends of S&T, with the antinomy of calling for increment of its *generic* potentiality - to make it more accessible to all operators - that should result from an increasing competition through localized technological changes.

The following three parts deals respectively with each one of the three organizational levels: the political, the governing, the operating S&T. The aim is to better focus the *direct* role of each level in *problem-solving*, in order to be able to make the S&T policy protocols more concrete.

The *part related to the political level* focuses on the governance problems in a geo-political scenarios of turbulence oscillating between the tendency towards an increased homogenization and 'corporatization' of the world and the tendency towards of an increased multipolarism and exaltation of local diversities. S&T might help in following a trajectory out of the bifurcation towards new equilibrium where an higher degree of homogenization is compatible with the valorization of differences. The task will be facilitated by a 'vision of the world' (a scenario) that foresees the development of continental regions including both a part of the North and of the South of the world. S&T can be instrumental to the realization of such a scenario, if a policy can be developed (a *co-evolution pact* between the different actors in the region) to solve the antinomy of asking an increase of the generic value of S&T (to broaden its accessibility) while at the same time pushing for localized technological changes as a mean to bring out the value of differences.

The *part related to the governing level* will focus on the institutional problems that emerge as a major difficulty in trying to organize a response to the globalization issues that requires a world-wide level action. The success in developing international actions on problems such as that of the ozone ring is encouraging. However, there are case, e.g. global warming, which are much more difficult and for which the un-

certainties at political, institutional and scientific levels mix ⁸ In these cases, there is the danger that the impasse due to specific difficulties at each level (e.g. the resistance to transfer responsibility from national to international levels) are inputted to the difficulty that S&T develops technical fixes to the problem. The institutional and organizational aspects of the globalization challenges therefore require to completely accept the evidence of the intrinsic difficulties due to the systemic effect and the need to change our approach to problem solving.

In the *part concerned specifically with how to organize the S&T response* to the globalization challenges, the various ideas and remarks of the previous parts are re-considered to develop a practical proposal that passes from the development of a general taxonomy of the globalization problems (and the related best suited solving approach), to the needs and difficulties to plan for S&T intervention.

Finally, in the *last part*, a grid is developed with the intention to be create a portfolio of proposals for R&D actions related to globalization issues. A tentative description of the terms of reference for some R&D proposals follows at the end.

⁸The first difficulty with global warming comes from the uncertainties on the extent it is a real issue. Furthermore, no technical fixes seem available to deal with the problem. If it is a real issue, are *slacks* still available to innovate at *component* level? (increasing the efficiency in power generation and use). Could we instead hope for radical technological changes to produce *new spaces*, or will we be forced to live with a saturated system? (see Part III)

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Part I 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.

The pervadence of the globalization processes is an index of the complexity and interdependence which are the marks 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.

We have insisted in the Introduction that protocols for actions, dealing with S&T, should involve all the organization of society. from political, to governing, to operating levels. We are impressed by the scale of the globalization issues. Such a scale cannot be addressed without a general world solidarity. But, has globalization helped or not to develop such solidarity?

Our perception of the globalization issues and the way we react to them, will depend from our *vision of the world*. May we forecast a world characterized by a more cosmopolitan spirit in which solidarity (crossing local, regional, continental and racial barriers) is an important accepted value? Or, the increasing difficulties to live in a too interactive world, will lead to more parochialism, local selfishness? If we think that we have reached a phase of "*end of history*", that is permanent stability, will this hypothesis enhance our ability to cope with the global issues or instead will it be undermined by the emergence of a state of endemic local instabilities?

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.

We know that we need proper actors to deal with each globalization problem.

Has globalization helped in allowing new actors emerge - especially at international level - or in solving the conflicts of competences and roles among existing ones? Will the networks of existing international governmental and non-governmental organizations increase or decrease their power as a consequence of having to deal with globalization issues? Or, will the increasing difficulties related to coping with these issues bring about a decline of these organizations' role?

What patterns emerge in international problem solving capabilities? And, furthermore, how globalization affects S&T itself?

The role of S&T will depend upon its portfolio of ideas, and upon how much it covers the globalization issues. In the Introduction we expressed the doubt that such

portfolio is rather empty. However, due to globalization an interesting change has taken place in S&T. Global networks have wrapped around S&T communities. Will such globalization trends assure a better capacity to tackle the globalization needs of S&T?

Indeed, one should look carefully to the noticeable *globalization in both Science and Technology*. It might have important effects in our capability to set priorities among several "physical" globalization challenges, and to monitor and alert on challenges development. The globalization of Science might have the effect to shift the agenda of basic research towards topics that are 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?

For all these reasons in this Part we will indulge to analyze the *patterns of globalization* in *geopolitics, economic development, international organization and S&T*.

In the Introduction we have underlined the importance of the interaction between problems and problem-solving process. The remarks on the related difficulties apply to any complex issue in which the intrinsic non-linearities emerge as feedbacks of the same order of magnitude of the direct cause-effect. We have assumed that this is the case for globalization. In this Part we will try to support these statements by an analysis of the globalization patterns.

In *summary*, 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.

Therefore, the external dynamics of the entire system which evolved in the mean time posing new problems on the board, changing actors' role and power, should be added to the internal dynamics of the problem solving loops - which is intrinsic to complexity.

One important aspect that interests us in this context is to trace how the increased interactions has produced incipient structural changes in the international system: in particular the forces that have increased their ranges at global scale becoming the determinants of the emergence of new subsystems with a global span and the related global actors.

1.1 The patterns of globalization in the international scene

The impressive scale of globalization problems emphasizes the availability of resources. As indicated in the Introduction, unless we succeed in better using available resources or developing new ones, we will have trouble to deal with globalization issues.

To meet these objectives it is necessary that the 'actors' of the 'world system' cooperate. Unfortunately, the scarcity of resources induces a situation of continuous potential conflicts among actors. This is true at local level (intra-society conflicts) as well as at international level.

The contentious situation is fueled not only by the scarcity of resources (contrasts in satisfying the different needs of individual actors) but also - when resources are in principle available - by the actors different perceptions and their consequent different priorities of allocation.

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 actors perception of priority of needs. The contrast assumes dramatic dimension in the North-South relationship. The analysis of past experience confirms the difficulty to develop a cooperation framework at international level.

In this chapter, we will analyze the historical trends of international trade development, the attempts to develop international solidarity between richer and poorer countries, the alternative 'views of the world' that accompany the various attempts to develop patterns of international relationships.

Is it possible to trace a trajectory of these tendencies leading to a 'vision of the world' that characterize the emergence of globalization? The answer is not an easy one.

Indeed, globalization, apparent as it is in terms of the new challenges posed, might not have had yet enough time to overcome the inertia of existing intra- and international structures. As a consequence, a scenario that contradicts the vision of a 'global village' world emerges.

Actually, many signs seem to indicate the emergence of an increased regionalism (may be, macro regions including areas of both North and of the South), and then, a multi-centric world with a certain degree of 'mercantilistic' attitude towards international trade. Will such a scenario influence positively our ability to deal with the globalization challenges?

At this point of the analysis the only possible conclusion is that, by trying to trace the emergence of new patterns of globalization at geo-political level, it becomes very 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.

We will resume in Part II the debate and try a deeper analysis with the objective to make policy recommendations that regard the 'political' level.

1.1 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*. Although these goals have not necessarily been mutually exclusive, our society will hardly escape to face this controversy in the future.

Albeit a wide approximation, one can say that *efficiency* is the core value of *liberals*, who consider the market as the best instrument for resources allocation. From their point of view, consequently, the role of the state should be minimized. Differently, generally speaking, *equity* is the underlying value of *socialists*, who state that the market fails to assure an acceptable distribution of wealth. Therefore, from their point of view, the state should heavily intervene with a redistributive function.

The conflict between efficiency and equity has been transposed at international level, particularly in a North-South perspective, in the following terms.

The *liberal approach* has stressed that the diffusion of wealth takes place through the international division of labour based mainly on the comparative advantages theory. Consequently, it has backed trade liberalization. In the liberal framework, transnational corporations (TNCs) have been seen as development instruments. On the contrary, the *socialist approach* has underlined the uneven worldwide distribution of the gains brought about by the international division of labour and trade. From such perspective, TNCs have been seen as instruments of exploitation. The sustained growth of the North, or 'core' of the system, has been possible only through the long term exploitation, and therefore underdevelopment, of the South, the 'periphery' of the system. This idea is the essence of the so called *dependency theory* of development.

The explanation of LDCs underdevelopment has been, of course, different according to these two approaches. For liberals, the main constraints preventing LDCs from taking advantage of the opportunities offered by the capitalistic system are local. For the advocates of the dependency approach, on the contrary, LDCs have been locked in a vicious circle of poverty and backwardness by the capitalism system itself. Accordingly, the only solution would be the change of the system and thus, eventually, the revolution. In this theoretical framework, LDCs called for a New International Economic Order in 1974.

After World War II, these approaches have had alternate popularity, with the *dependency* one having been on the wave mainly in the 60s and early 70s, and the *liberal* are regaining consensus in the '80s. The shift has been the result of a number of causes. The backers of the dependency theory have not been co-ordinated enough, have lacked sufficient economic and military power, and, at the same time, they have been unable to formulate viable alternatives to the existing system. The failure of socialist experiments has strongly weakened the position of socialists. Finally, the conjecture about the impossibility to break the circle of underdevelopment has been deeply challenged by the achievements of NICs. *Liberals* have promptly exploited both such successful experiences and socialist failures to support their thesis, that it is possible to develop within the existing system.

This brief review of geo-political trends suggests a first consideration. Due to historical evolution, including the fiscal crises of last decade *the market has regained the central position* as a mean to organize production at both national and international levels. Most LDCs have either spontaneously accepted the pre-eminence of the market, or they have been forced to do so by the conditionality attached to the adjustment lending programs sponsored by international finance institutions (i.e. World Bank and IMF).

Besides efficiency and equity, there are other values pertinent to the economic analysis of the international system. In a system of nation-states such as the one in which we are living, the *national interest* is still a fundamental value. The revival of (economic) nationalisms in different parts of the world has induced some scholars to talk about *new mercantilism*.

Originally, mercantilism developed in the new system of nation-states of the XVII century, and was characterized by the intervention of the state to defend national security and integrity, along with national reserves. According to the extreme interpretation of the mercantilist view, there was not common gains from free trade, as one nation's gain represents one other nation's loss. Therefore, governments heavily intervened through trade policies in order to protect local production. National interest was beyond any one else, and, thus, the system of values accepted within national boundaries was not usually valid outside them.

National-states remain central actors within the existing system. The release of national sovereignty to sovranational institutions has been very limited so far, even in the economic realm. The EC represents the most advanced model of economic integration and authority delegation, but most other countries lay far behind in such process. States have largely maintained the power to intervene to regulate factors and goods mobility, hence transnational production. They can still give up part of the gains from global growth and interdependence in exchange for the benefits above mentioned (i.e. integrity, etc.).

Can we define a next phase in the international development scenario? In order to take into consideration economic integration, it is possible to talk about *regional mercantilism* (fortress Europe?). The mercantilist approach is somehow appealing for states, or regions, that suffer international competition and have enough resources to afford a certain degree of autarchy. While virtually every nation is not self-sufficient, some scholars have hypothesized the *development of loose regional blocs*, such as the pacific one led by Japan, the European one led by the EC, and the American one led by the United States. It is also possible to think about an African region led by South Africa, and of course about China and India. In a regional mercantilist world, within regions factors, goods, and knowledge mobility is potentially perfect, while between regions mobility is limited by the intervention of regional authority. The degree of inter-regions mobility can of course range from total autarchy. to complete liberalization. Of course, the latter extreme of the continuum, of course, overlaps the perfect liberal system.

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 mercantil-

ist. The relevant question is what will the relative importance of each priority be. Any change is bound to have a redistributive effect of costs and benefits among actors. Consequently, the lobbies representing different interests will compete to influence the direction of such changes. Each actor will try to control the vital ganglions of the world economy, one of the most important of which is science and technology (S&T). Their relative bargaining power will determine the final outcome of the current turbulence.

1.2 The great debate: the North - South interactions

The prevailing problems on the international agenda have been that of trade and of the relations between N and S. The bipolar repartition of power has dominated the international scene and had direct and indirect impact on the entire process of dealing with the problems agenda.

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 shows also that the painstaking long trajectory of the industrialization in the North can hardly be followed by the South because of the increased interactions due to globalization. However, this implies a lot of doubts on the alternative ways to develop the needed change (including the change in the context). 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). It is possible that leapfrogging (i.e. improvement of social services and infrastructures, then industrialization, followed by better services, etc.) may take place through international solidarity. The problem is how likely is the development of a solidarity of the needed scale.

While a limited number of LDCs have managed to escape from the vicious circle of poverty and have moved along the path of economic development, most of them are still lying far behind.

The so called "*new international division of labour*", which has contributed to the take-off of a number of Far- and South-East Asia countries, has left wide areas of the South largely untouched. Only few countries have had the minimum economic and political stability, as well as the human capital and the appropriate economic policies to attract and take advantage of TNCs and export opportunities.

For the other LDCs, the *old division of labour* based on primary and agricultural products specialization has probably remained valid so far. In these LDCs, internal factors have limited their capacity to exploit the few opportunities of development provided by the system. Their future is as uncertain as before.

During last decade, the new resources available for investment programs have been extremely scant, mainly due to the debt burden. The decline of the state, especially

in Africa, has strongly contributed to the misuse of such resources too.

So far, adjustment programs have had virtual no impact on growth. International finance organizations have *forced these countries to liberalize their market*, but most countries have faced difficulties in taking advantage of international demand. This has partially been due to their weak supply capacity, to the rise of protectionism in DCs, as well as to the limited increase of primary products demand. There is wide agreement on the evidence proving that in the last decade the terms of trade for countries specialized in primary and agricultural products have declined. The future does not provide encouraging perspectives

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 development process, not last, among donors countries and institutions.

LDCs would benefit from worldwide financial stability and growth, new flows of capital, diversification of production, release of protectionism in the North, creation of regional markets, political co-operation to give momentum to the political process towards multi-party systems and democratic regimes and regional co-operation.

While in the short term LDCs may suffer from Easter countries competition on aid resources, in a longer perspective they may benefit from the improvement of economic and political collaboration at world level.

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 opportunities.

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 (i.e. transfer of the systemic approach), 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

To a large extent this positive perspective depends very much upon the level of 'solidarity' of the rich countries of the North. However, one may ask *why the EC and the OECD in general, should continue to co-operate with or aid the South*. Here is where the increasing interdependence of globalization help to draw a more positive scenario. Generally speaking, there are three types of answers.

The first is *humanitarian*. The underdevelopment of a large share of mankind represents a global failure for our system. From this point of view, brotherhood and solidarity are the relevant values inducing international co-operation. The second and third answers are *utilitaristic*. LDCs represent a *market* for a large number of goods produced in OECD countries. In order to maintain this function LDCs should increase their purchasing power. At the same time, TNCs need complementary conditions such as stability and infrastructure, in order to take advantage of LDCs labour cost. Finally, LDCs may represent a *strong element of disorder* in the system. On one hand, local conflict may escalate to global level. On the other hand, LDCs cooperation is necessary to solve some global problems and, particularly, the environmental ones (i.e. Brazil with Amazonia). Last, but not least, LDCs may introduce disorder through unsustainable migration flows.

Summing up, the importance to keep supporting LDCs, lays in the fact that LDCs development may contribute to the long term well-being of the system members, including the EC. What the EC should do in practice in order to contribute to LDCs recovery is not an easy question. In the field of technology some general indications have been reported in the previous section. However, one should compare the political and economic power of EC with that of other actors, especially TNCs, to assess the capacity of the EC itself to correct undesirable trajectories. To this respect, it is likely that the strength of EC actions depend on its capacity to define clearly the values which matter.

1.3 Towards a 'regional mercantilistic' scenario

The problems of North- South relationships are not only important because of the relevance of the South problems. The future geo-political scenario depends on the way these relationships will evolve. In turn, the geo-political vision of the world will have strong effects on the possibility to solve the South problems.

Can we dear to trace an emergent scenario that be the results, but also the preconditions, of globalization? To attempt this task, we have to consider not only the historical trends in international development and the corresponding visions of the world, but even more important, to look for the determinant of changes that characterize the globalization process.

1.3.1 The determinants of changes

At the moment, the following global forces seem to be of utmost importance : *i*) demographic change and long-term unemployment, *ii*) environment degradation, *iii*) militarization and nuclear proliferation, *iv*) political change in the former socialist system and growing call for democracy, *v*) economic liberalization (deregulation-new protectionism) and *vi*) S&T development.

i) *Demographic changes* are bound to worsen the already existing *long-term unemployment* problem and its financial and social repercussions. The bargaining position of labour vis à vis capital is like to be further weakened by the increasing gap between the availability of the two factors. This will continue to create conflicts among workers themselves to get access to scarce factors (e.g. housing), as it has already happened in OECD countries between migrants and poorer locals.

ii) *Environment degradation* 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 increase the risk of regional wars, especially in LDCs, with possible global escalations. They also reduce available resources for investment in other sectors.

iv) While these forces have negative features, we are also now spectators of *unique positive political changes*, particularly those taking place in the *ex-socialist block*. To the extent that the previous bi-polar political system was a main constraint to the solution of global problems, such changes are potentially far reaching.⁹ Worldwide, the *call for democracy* has strengthened in the last decade. There is a common hope that human, political, as well as social rights might be more extensively recognized in the future, also through multi-party systems which are expected to reduce the risk of war and improve governing capacity by limiting the personalization of politics. Such a process is a pushing factor towards peace and economic development. There is expectation that the decline of the bi-polar system may give momentum to the democratization process in the South. In fact, authoritarian regimes have often been supported by superpowers in exchange for political affiliation.

v) Turning to more specific economic changes *economic liberalization* along with S&T development have been the most powerful factors in promoting the transnationalization of economic activity during the last decades. *Trans-nationalization* should be intended in terms of both trade and production. As far as *trade* is concerned, so far there have been ambiguous tendencies, as proved by the difficulties faced by the Uruguay Round of GATT, and, as mentioned above, the general concern about future EC trade policies. Even among scholars, there is not general agreement on future trends. At world level, however, the global degree of protectionism has declined as a consequences of the diffusion of the structural adjustment programs in LDCs. The pattern of *transnationalisation of production* has been much more straightforward. The risk of protectionism and the gain from the common market has induced Transnational Corporations from Japan and the United States to invest in the EC. Furthermore, the general attitude of LDCs toward TNCs has changed compared to the '70s¹⁰ in favour of greater liberalism.

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

⁹They have unlocked a great potential for co-operation, as well as human and financial resources (i.e. reduction of military expenses). At the same time, however, they have introduced a strong element of complexity and uncertainty (irreversibility of changes, ethnic conflicts, nuclear control, and so on). They have also strengthened the competition for capital.

¹⁰As a consequence of the adoption of a more pragmatic approach and of the general scarcity of capital due, among other factors, to the debt problem, LDCs have gradually opened their economies to TNCs. They have actually become competitors as the supply of foreign investments have not met the demand. As a consequences of the above mentioned changes, potential markets for TNCs have widened.

of host countries. Localization and dispersion costs have been reduced, allowing TNCs to exploit localization and dispersion benefits. The reallocation process has mainly take place in South-East Asia.

The liberalization of markets, especially within the EC, has been functional to the exploitation of R&D potential. In fact, efficient R&D investments have increased, requiring an enlargement of the minimum scale of output market. For a number of products, especially components, such scale that was already beyond national one dimension, has become global. The *reduction of economic discontinuity among states and S&T innovations* have strengthened the role and power of TNCs. From the perspective of the models described in previous paragraphs, these two forces have pushed the system along the "*liberal*" trajectory increasing economic efficiency.

There are however contrasting remarks pertaining to S&T and LDCs to be made. The forces, such as the labour cost, which have induced TNCs to localize some productions in LDCs, will remain powerful in the next decades. Nevertheless, *complementary trends which promote production reintegration in TNCs home countries* (mainly OECD) have recently emerged in some sectors.

The case of the semiconductors industry¹¹ is useful to understand that *the pattern of transnationalisation is not homogeneous* but depends on a complex interplay of costs and benefits at sectoral level. In any case, however, S&T plays a decisive role in influencing such interplay.

A final reminder on the economic nature of S&T is necessary to understand S&T evolution and the room for policy intervention. Technological innovation is the result of an investment. 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. One can safely assume that such a logic will prevail also in next decades as firms will hardly change their nature of profit maximizer.

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.*

1.3.2 The emergent economic-based scenario

Taking into considerations historical trends and the effects of current forces, can we attempt to describe the emergent geo-political scenario making use of past ideological labels? The reference to past ideologies might limit our ability to feature new radical characteristics of potential scenarios. Nevertheless, we will stay here with such a bound and briefly describe a scenario that is already a change with past trends, and amplify some new emergent features of international politics.

¹¹In the semiconductors industry, for example, the labour content of production has declined. Assembly activity has been to a large extent automatized with gains in terms of quality. The demand for customized products, which require geographical proximity between supplier and client, has increased. Labour processes have been reorganized according to the "just in time" model, which, again, benefits from market vicinity.

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. There are some authors who claim that the reaction to old ideologies and policies has gone too far. However, at the moment the free market keeps receiving wide appreciation. Nevertheless, at the same time there are forces leading along the direction of the mercantilistic model. Some pressure groups support the introduction of controls on the mobility of labour and goods. In the EC, for example, some controls on immigrants have been enforced and protectionism has been maintained, especially in the agricultural and automobile sectors. Protectionism is preferred by those countries, and within each country, by those sectors which are the weak partner of the trade system. Policy makers justify trade or industrial policies with the need to restructure threatened sectors, support employment, protect strategic sectors, and so on. From this point of view, it is not difficult to understand the Japanese liberalism. The future trade policies of the EC are not clear yet.

How to fit LDCs in the scenario remain a very uncertain aspect. One possibility is the development of *regional clusters including LDCs*. It is difficult to say to what extent the mercantilist tendencies represent a step towards that direction. The geographical distribution of foreign investments, aid and trade flows has controversial trends, although geographical proximity is certainly an important factor. The EC involvement in Africa is relatively larger than that of Japan, indeed, but in South America, for example, European, Japanese, and American interests are more mixed up (e.g., consider the special relationship between Italy and Argentina). Furthermore, LDCs regional co-operation is made difficult by political instability and economic constraints: there are much less gains from trade in regional markets of limited dimensions and little differentiated productions (e.g., agricultural products).

The limitation of the negative effects of the pure liberal model, such as inequality and uniformed culture, depends on the restriction imposed on the factors strengthening the power of TNCs and, more generally, the process of trade and production transnationalisation. However, further research is needed to identify solutions which, while introducing growth-oriented redistributive mechanisms, have the lowest cost in terms of efficiency. Some scholars have argued that not only governments but also new international political forces, such as Churches, voluntary (e.g. greens) and labour organizations can exercise control on international capital. They need to enlarge their scope and become more institutionalized. They would also need broader access to S&T, especially in telecommunications, and, maybe, a step in productive units. Their action could influence time and allocative preferences, as well as strengthen international growth-oriented redistributive mechanisms.

To be able to venture more radical features in the scenario description we would have to examine more in detail potential structural changes. To this effect we have to extend our analysis to the institutional/actors level. Are new actors having a 'global dimension' emerging as a consequence of globalization? Let us start by analyzing the pattern of globalization at *institutional level*.

1.2 Globalization and international actors development

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, among massive allocation of resources. In other words: global policy problems deserve to be faced through international coordination.

Around specific issues, institutional arrangements and formal organizations can exist or are created. Global policy problems are also addressed in a variety of ways. Each method has its own strengths and weaknesses which deserve careful assessment.

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.

Among IGOs, the framework of the United Nations (UN), both in its central organs or in the family of affiliated agencies, is particularly relevant. As far as MNCs are concerned, their role as primary agents of technological transfer is widely documented. So the easy assumption is made that the international framework and environment of the coming decades will be extensively shaped not by governments and IOs alone, but by the interaction with MNCs as key-agents in the international arena.

Finally, 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.

The analysis of the international system needs to be focused on governments and International Organizations (IOs), with the aim to assess problems connected with cooperative and confrontational issues among countries that are S&T related.

Key questions in analyzing the S&T international policy-making process, are:

- how can actors address and procedurally succeed in forming institutional arrangements and agreements to cope with global problems involving S&T and TT problems in a multi-polar framework? What criteria must such agreements meet?
- what obstacles are faced by global policy-processes, and which arrangements could be designed to overcome or attenuate collective action problems in coping with global problems?
- how the globalization issues utter and are described/ classified in the international organizations?
- how private and public interact in globalization, such as in the cases of international agreements in matters characterized by business competition?

International policy procedures and protocols have been considered in different studies. Even if there are few efforts to value their effectiveness and even if we have few

reasons to be optimistic about, there is an extensive quest for operative approach in improvement and effectiveness.

2.1 The structure of governance: institutions, strategies and policies.

Institutions and Fora have developed in parallel with the different phases of the geopolitical globalization as an attempt to provide global governance. They are located on at least three different levels.

The *first level* of *International Institutions* created mainly after the Second World War under the impulse of U.S.A. They are distributed on two sub-levels:

- a. *Political Global Institutions*: the UN and their families belong to this sublevel.
- b. *Financial Global and Regional Institutions*: the IMF and the WB Group, which includes International Bank for Reconstruction and Development (IBRD) (the only institution financing projects for long term economic development) and its two affiliates: the International Development Association (IDA) (credits to very poor countries) and the International Finance Corporation (IFC) (loans and equity investments in the private sector of developing countries). Plus regional replicas: Inter-American Development Bank (IDB) (development assistance to Latin America and Caribbean developing countries); the Asian Development Bank and its affiliates (financing economic development in Asian and Pacific rim developing countries); the African Development Bank (AFDB) (loans on market-related terms to higher income African countries), and the African Development Fund (AFD) (loans only to the poorest African nations).

The *second level* is that of *Northern informal as well "exclusive" membership clubs* that grew up in the Seventies and Eighties and of which the OCDE is the oldest.. Some enlightened politicians and entrepreneurs of the Triad carried out a great deal of initiatives. A wave of first class clubs flourished in the middle of Seventies. Even if the most important of them remain the Groups of 5 and 7 initiated under Giscard d'Estaigne, also others - such as the Crocodile club by Spinelli, the Club of Rome by Aurelio Peccei, and others - were set up. The clubs mood was the attempt to both give a response to the cute perception of the growing interdependence among economies, and to try a first approach to the management of highly dynamic and competitive economies. The club wave, and in particular G-7 summitry, was also a counter-strategy to South conquest of open International Institutions.¹²

The *third level* is mainly due to the *re-shaping strategies of Third World Countries*. The general goal of developing countries of moving toward more authoritative international regimes has been pursued using two specific strategies. First, *by creating new IIs*, such as UNCTAD (United Nations Conference on Trade and Development), to offer a counterweight to Gatt. *UNCTAD aims to limit "the discretionary behavior*

¹²In Part II we will illustrate the importance of the so called 'summitry' institutions in international dealings.

of Northern actors by redefining property rights, including, in most extreme case, compelling additional resource transfers from the North to the South.¹³ Secondly, by supporting and enacting international regimes that legitimate *the right of individual states to exercise sovereign control over a wider range of activities that are universally accepted as subject to the unilateral control of the state.*¹⁴

2.2 The increasing deficit of governance capability

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.* The institutional base and the policy processes are inadequate to deal effectively with changing situations such as:

- The *transition toward a multipolar world based on the Triad* (United States, Europe and Japan) on one side, and on the other *on the growing economic dimensions of former Third World countries* such as ASEAN countries, Mexico, Brazil, and others, *or the transition to market economy of former Second World countries* (Poland, Hungary, Czechoslovakia, ex-USSR, etc.). In spite of this process, there is a lack of global governance. International policy-making, embodied in International Organizations, is affected by a *deficit in multilateralism* (as expressed by the disarray in the GATT process) and a *loss of leadership.*¹⁵ All this provokes growing instability and uncertainty in the international political economy as well as a rising tide of protectionist pressures.
- 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. Fear of a loss in relative position of power and wealth can prevent governments to widely pursue synergistic gains in international cooperation.
- The growing interest in *regional trading blocks* as epitomized by "Europe 1992" and US-Canada-Mexico FTA. In the EC, the burst to greater regional integration has been largely generated by a need to improve competitiveness and rationalization of European industry, especially in high-technology sectors, alongside United States and Japan. 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.

Even if specific outcomes are difficult to forecast, the loss of a unifying threat inside the western advanced industrialized countries (AICs), will indubitably result in the *waning of a major force inhibiting a more overt economic confrontation.* This shift amplify a long term trend toward the erosion of American hegemony inside the

¹³For instance, the Law of the Sea Convention provides for the compulsory transfer of technology from multinational corporations to an international entity called the Enterprise, the operating instrument of the International Sea-Bed Authority." (see Krasner, p.6)

¹⁴Krasner,1985 p.6..

¹⁵The reference is to the triadic group portrayed by an author as "*an odd trio of a leader without hegemony and two potential hegemonies reluctant to assume leadership*" (Ostry, 1990)

2.3 The impacts of S&T on international governance capability

Since technological development and international technological transfer is expected to play an important role in solving the enormous economic, social and environmental problems which affect the world and particularly the less developed countries, we should expect a contribution on governance from S&T itself. However, scientific development and technological change (as *generative paradigms* of ongoing processes of innovation and modernization) far from weakening, are increasing *at a much greater rate competition and conflict and amplifying the divide between rich and poor nations* in the international arena.

Even during the period of sharp confrontation and of willingness to assert U.S. strength and leadership of the Reagan administration, the working of fundamental shifts in the distribution of power and resources were apparent in the economic sphere. *The alteration in the allocation of economic and technological resources - especially between Japan and the United States - had an impact also on international politics and global security.*

During the 80s the *defense-related potential of Japanese technological and economic achievements* was recognized among U.S. government circles. The undisputed leading role of American pure military technology left room to a growing dependence on Japanese civilian technologies with military applications (dual technologies), notably in electronically controlled weapons systems. But even the U.S. macro-economic dependence on capital inflows from Japan made clear the *American "strategic" dependence on Japanese financial resources* in big military and technological efforts, such as those epitomized in SDI. The future impact of Japan increased international leverage - and how that leverage would affect the structure of international power distribution in the international system - must be framed inside this crucial shift.

As far *LDCs* are concerned, the collapse of bi-polarism and of global Soviet-Western military confrontation can result in a *huge loss of bargaining power with respect to the core-actors in the strategic arena*. At the other end, the fear of shifts in global economic power coupled with an increased *competition among DCs, will predictably further restrain the transfer of new technology* because of the increasing understanding of the strategic advantages offered by S&T in economic competition. ***Growing frictions related to the access to S&T and boosted desires to get scientific knowledge and transfer under control will most likely fuel new strain to international relations in the foreseeable future.***

Very insidious are the combination of all these potential sources of conflict with the growing independence of global economy from states and political institutions and, at the same time, the variety of emerging dramatic developments and transformations fostering toward growing interdependence in world affairs. Trends and factors like the growth of international trade and foreign investments, the massive flows of people and information across borders, the growing sensitivity of national societies toward processes and activities occurring abroad but with major domestic consequences are examples.

As a consequence, the government inability to cope with problems that basically affect national societies but deserve an international and even global approach may worsen.

2.4 The emergence of structural changes in the world system

The above analysis of state of governance and of its ability to deal with globalization shows a critical situation which parallels the feeling of confusion when one tries to describe geo-political trends. We cannot but feel such state of confusion 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. We have therefore to look for incipient signs of more radical changes.

2.4.1 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. To trace incipient changes we should look at the determinants of change which are specific of globalization, namely the effect of the increased range of interaction.

Do we perceive patterns of globalization that affect the structure itself of societal systems? Are new *global sub-systems* that might lead us to forecast an organizational transition from international institutions to really global ones emerging? Are new 'actors' (such as 'networked' TNC's) having a 'global' span that might be a determinant of such change emerging?

However the emergence of new actors might make even more problematic the ability to approach challenging issues. When new sub-systems appear we say that the system has gone through a radical change. However when we start appreciating the emergence of new sub-systems the change might be far from complete and the system still be in a phase of transition. In such a case 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-systems 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. Is this situation acceptable or the sub-system has to grow in a way to include the ability to control its own dynamics?

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? Can we envisage that the scientific community subsystem, by increasing its internal power, becomes more globally structured to exert such control?

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. The problem here is to what extent the "*global market*" (for the products that enter into it) is a sub-system that has its internal rules of control. 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?

The quick remarks above indicate that 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 question, relevant for S&T policy, to be posed is whether or not one can somehow prevent each subsystem from entering into damaging oscillations.

In the *financial case*, IT&T have been instrumental to allow a world-wide sub-system to emerge. One should look at IT&T also to develop an internal control system. The major problem to solve is likely to be more institutional (who can conceive and implement action at world level?) than technological.

As the *globalization of economy*, one has the impression that there has been an "overshooting" in trade, through the exploitation of spatial disequilibria, also at social level. It is important to analyze industrial and service activities to distinguish those that have an intrinsic world-scale level from the others. Not all firms have to develop as multinationals oriented to the world market.

The *revisiting of the technology transfer issue* might here help, specifically to interconnect the roles of generic and specific technologies: components and materials (which integrate "localized/specific" technological knowledge, but are designed for "generic" use) should aim at world market, while final products/services could be more local/regional market oriented.

The above remarks support the idea that we are in a phase of system transition. The underlining problem is the increasing gap between the problems that emerge and the ability to deal with them. This is due to the fact that system restructuring, which is not complete, has often induced a separation between the sub-system where the problem emerges from that where there is the ability to solve it or, on the contrary, the has shifted the problem to an institutional level more adapt to respond to the problem without transferring the necessary resources.¹⁶

Unless the institutional changes necessary to deal with the problems that cannot be 'delegated' to existing institutions are anticipated, it is not useful to list the potential contribution of S&T. How can we call attention for the necessity to develop appropriate institutions and develop 'ad hoc' methodologies to approach the globality issues?

¹⁶See, e.g., the case of the debate on the role and on the budget of the EC on environmental issues.

2.4.2 *Approaching a phase of structural change*

When the 'global system is close to undergoing a structural change, it provide signals which are characteristics of such condition. Among them is an increased amplification of perturbations. Since problem solving depends on the system structure (old and new actors), can we hints at the general features of the emerging new system?

To depict the future scenario in term of system structure, one could use of the following *conjecture on open systems dynamics: an open system reacts to the increased complexity by restructuring itself in a hierarchy of complex open sub-systems so framed to be able each one to deal with their internal problems and with their environment with as less as possible intervention from other sub-systems.*

The conjecture on 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.¹⁷

According to this conjecture, 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.¹⁸

The conjecture will have an impact on the institutional/ organizational structure and in general on the overall capability to address and solve problems. In fact, if the subdivisions between sub-systems - including the new ones - are clear (which is usually not the case in a transition period), the actors of each sub-system (policy makers, decision-makers, public at large) would know that to face the perceived needs they should look inside itself: *to define first of all what the real problems are (problem definition), and then provide solutions.* It should be the tasks of 'global' sub-systems (which might be completely new and not only re-arrangements of existing ones) to deal with global needs.

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. A 'local' subsystem might be faced with new issues that derive

¹⁷ To help understanding let us take a case which might be controversial: the past and present relation of the North and South of the planet. *Colonialism* was an equilibrium structure. The imperial nations created problems (as well as opportunities) by their occupation of colonies. But they had the power (often brutal and non-democratic) to react, to find solutions. The relation between North and South of today poses new problems (for instance the contrast between technology and culture) or changes in the old ones (such as the production in the South for the North market). However the ability to even start defining what are the problems to be solved, become more and more difficult lacking a unitarian sub-system that have the power to intervene.

¹⁸ J.N. Rosenou (Turbulence in World Politics, MIT University Press, 1992) forecasts instead a period of **stable biforcation**, an oscillation between two different states of world (from state-centric to multi-centric) as a permanent condition.

from the interaction with 'global' sub-systems (part of the system environment, e.g. the world-wide media). Also in those cases the basic attitude of subsystem actors should remain that of finding in the sub-system itself the ways and means to solve the related problems.

There might be therefore a lot of sub-systems new problems which remain local or regional in nature although they originates from the sub-system environment which include *globality* (e.g., the problems emerging from the immigration pressure on Europe).¹⁹

2.4.3 The changing ranges of interaction "forces"

To grasp current and expected changes (to understand the signals coming from the *global* system), 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. Only the sharing of the same spatial "niches" by different "races" (with different styles and qualities of life) poses problems (see the recent change in Italy concomitant with the immigration from Africa). However, the addition of religious integralism, might create strong racial antagonisms even when there are not close contacts. An increase in the "range" of the racism "forces" (of continental, if not a world-wide dimension) is today apparent.
- **Social solidarity**: in the past, social solidarity was of short range nature. One helped the poor that physically encountered. 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 (at least for emergency, catastrophic events). The fact that the new technology of the media has made the world appear like a small village, has certainly favored such evolution
- **Markets**: with the development of communication in the modern era, products having a "world-wide" markets have emerged. However, for centuries most of them could be classified as "exotic" or "niche" products. The increased pace towards a world market for a larger and larger numbers of products is a recent phenomenon. For certain class of products, including mass ones, we can now talk of

¹⁹The scenario and the recipe might have to deal first of all with the paradox that, while there is an increasing feeling to be citizen of the world (the effect of the globalization), local fights between small local regions increases. This could be an indication of how deep the effect of re-arrangement at all level of system structure might be and how strong the interconnection between forces of very different ranges.

T. Whiston (The Last Empire: the corporatization of society and diminution of the self, Futures, march 1991, pg. 163), sees the danger that the historical tendencies towards some form of social cohesion (with the related advantages of an increased ability to respond to challenges) actually becomes a sort of "Last Empire" that kills - through pervading conformity - the freedom and the realization of the individuals. The turbulence which is noticeable today, is the emergence of counter-tendencies against the trend to an increased conformity of "corporatization".

"standard" world products. This trend is of basic concern for our study. The basic issue is whether the trend will continue and extend to other products or whether there has already been an overshooting.

- Needs & problems: basic needs have always been universal, but not necessarily they have turned into problems of world-wide dimension. Here again an increasing number of needs have become "social" and the responsibility to satisfy them has been transferred from individuals to communities, 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. Concerning "universal" (having the same characteristics everywhere, but not being global) problems it has to be noticed that there is a trend of increasing regional or global cooperation between interested parties (e.g., the trend in R&D cooperation among competing firms).
- Science and Technology: science tends to be universal. There might be differences from one region to another in term of priorities of research topics. However, also from this angle, more and more Science tends to become 'global'. Probably the scientific community has already evolved as a 'global' sub-system with its own rules and dynamics (the last obstacles should disappear with the fall of USSR). The situation is different with technology. The basic obstacles preventing Technology from becoming 'global', are mainly related to the differences of technical standards and product specifications. However there is a trend to increase world technical standards. Should we foresee a world of standardized products? This is unlikely for final products which have to fit different user' needs in different regions of the world. Instead, one may expect to be the case for materials and components (especially generic technology ones).
- Finance: the information revolution seems to have already determined the development of a 'global' subsystem with its own characteristic behaviour and dynamics.

The conclusion from the above remarks is that there is in fact a shift of the dimensions of many "forces" that make human beings interact.

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.

2.5 Institutional changes: the effects on decision-making

The most important question concerning the globalization effects on institutions and actors we are here interested, is how globalization will impact the process of problem solving. And, since we deal with the governance level, what is the impact on decision-making. In fact, there are matters for concern on our *ability to deal with problem-solving*, and in turn respond to the globalization challenges, through present or new structures/ institutions.

In dealing with the decision-making process our attention has to be focused on actors. Actors are men and institutions. As we have above reminded, institutions have different nature. In the international system, the traditional institutions are the na-

tional states. Over time, however, institutions evolve and new ones add up (such as communities of national states, e.g. EC, international governmental and non-governmental organizations, transnational enterprises) also as an effect of globalization.

Different actors and institutions have different priorities. Indeed, they have different sensitivities to perceive challenges as well as different interests or points of view to defend. Cooperation should be the way to overcome contentious situations and search consensus for actions. This is always a difficult challenge at any level and certainly also internationally.

To find solutions, to proceed towards a common view and basis for action, a delicate political game has to be played. Globalization - because of the blurring in the separation of interests, problems and priorities - does not make the game easier to play.²⁰

As anticipated in the Introduction, it is not only a problem of developing more appropriate policies and strategies, but of learning how to deal with the problem solving in the new system conditions.

The more so, the more it is likely that the system go through turbulent structural changes. Therefore we might have to *verify if the speed of changes* indicates such a trend (at least concerning the technological trajectory). This is a prerequisite to be able to tackle our specific task related to S&T. In fact, to define the potential role of S&T in scenario building, it is necessary to adopt a longer-term perspective. In turn, this requires to take a system view and look for the systemic force at work.

While it is important to understand the effect of "globalizing forces", it is also important to see the change in the "system environment" for local/ regional/ continental sub-systems and the ways to react to such changes.

This concern should be the key one for the EC.

To complicate even more the perspective one has to be conscious that apart from the already apparent phenomenon of the emergence of new global sub-systems, if one take a sufficient **long term** view, there is the possibility of major system transitions that will force global system restructuring.

Can we already see the seeds of such long term structural changes? If so, this will have to be taken into consideration as a further criteria to select the priority issues, to organize the reaction to them and to look for alternative solutions that make less critical the transition towards further restructuring of the global system.

²⁰Globalization can be seen - from the international actors point of observation - as the development of interdependence among different actors due to the intensification of economic exchanges (goods, capitals, work-force) and of information (both media and tourism). The increase of interdependence determine an increase in the 'number of variables' which from the local point of view (that of the national members of the international organizations) will be seen as exogenous variables that are responsible in changing the historically built international environment which the local actors are used to assume as given (and on which is based the delicate power game to produce consensus on the issues under consideration). Therefore globalization is having - or could have - the effect to produce radical changes in the international environment.

In the next century four major system transitions have been hypothesized: *demographic, environmental, agro-food and urban transitions* in sequence.²¹ It might be of interest to speculate on the effects of such transition on the definition S&T policy.²²

Because of the relevance of S&T in responding to global challenges, we turn now to devote attention to what globalization has meant for S&T itself (as an actor), how S&T as a 'subsystem' is changing as a consequence of the general globalization wave of change.

²¹See, T. Gaudin (ed.), 2100 Récit du prochain siècle, Edition Payot, Paris, 1990

²²One important contribution to develop a portfolio of ideas for S&T, will be to translate the hypothesized transitions into R&D objectives:

demographic transition. S&T should help in accelerating the reaching of the saturation of population growth (how? through information, new drugs, etc.?),

environment transition. At individual level is important that some sort of automatism (ethical?) in behavior be developed to avoid environmental damage in everyday activities and choices. Is it an objective for R&D to help develop such individual behavior? How?

agro-food transition. Objectives for S&T seem here clear in term of accelerating "agriculture without earth". However there are other objectives that interrelates with the land use for agriculture (occupation of land to control natural events such as floods, etc.). Technology can help in developing more effective "marginal agriculture". Should this also be an objective to be pursued?

urban transition. Here S&T should help accelerating the trend towards de-urbanization. It could help by better transport and communication technology (both infrastructure and products).

1.3 The changing scene for S&T

Because of the relevance of feedbacks and related long term consequences, globalization compels decision-makers to consider longer term scenarios when defining policy, choosing strategies and planning actions. We know how difficult these tasks are due to the competition in scarce resources allocation (already so insufficient for what are perceived as short term urgent matters). The situation is even more difficult if the resources to allocate to long term issues have to be managed through international institutions and actors.²³

How will S&T contribute to simplify the problem? In this section, we start debating whether S&T (as an actor) patterns of globalization may could facilitate or not problem solving.

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? How can this happen? In this case the responsibility of the S&T community is clear. It would be difficult for the layman to assess the potential value of a new scientific discover. It is not an easy job also for experts. However the S&T community has its own means and processes to assess the potentialities of S&T, and, more important, to search for better paths to follow to explore such potentialities.

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? We have anticipated in the previous chapter that S&T, as an actor, has developed features that make it look as a 'global subsystem'.

How will this influence the capacity of S&T to improve the global decision-making process?

In this section we explore this issue and indicate in a preliminary way the consequences for S&T policy that derive from the globalization trends of S&T.

3.1 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 trends for public research?*

The phase of *internationalization* is the only one visible so far. Indeed, some public research organizations (universities or Contract Research Organizations like Battelle) might have established foreign subsidiaries, but only within an enterprise logic. Is it foreseeable that a public body - such as a National Research Council - sets up

²³In Part III we will analyze more in depth the problem, with practical examples that show the many barriers to overcome, the cases of partial success, the ones where it is extremely difficult to reach a consensus even on the definition of the problem at stake.

foreign laboratories (*multi-nationalization* phase)? What about the third step of globalization for public R&D? 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?

For enterprises, the market mechanism represents the push/premium for globalization. Is there a corresponding non-market mechanism for public bodies? Is it Defense (e.g. space)? Strategy (e.g. marine resource)? or Power (e.g. Antarctica)?

May we cope with globalization without building a sovranational organization? Let's take the **case of EC**. May it be considered as an example of a regionalization (globalization within the EC region) trend? The scope and objective of the EC R&D should be to deal with regional problems.

Can the EC R&D policy be considered as a kind of "global switching" (i.e. regional problem can be dealt effectively only at regional level) decided by EC members? .

It seems interesting to deepen the analysis of the *globalization trends of public R&D*, such as basic science studied at universities or applied research organized around public institutions such as NRCs.

3.1.1 Science networking

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', that has contributed to the utterance of the theme within the scientific community. To sustain the research activity in the informal network is not necessary an external flow of money, since each scientist finds the needed resources locally and his free to change his research agenda. The process however might not be completely spontaneous since it is *indirectly affected by public policies* promoting contacts, providing grants for stages in foreign institutes or universities (see as an example the NATO scientific grants program).

A recent effort to foster cooperation among European scientists has been pursued by the EC through the SCIENCE programme which explicitly provides the support for networking on specific research topics chosen by means of a somewhat competing mechanism (proposals and selection).

The European Science Foundation is also explicitly promoting networking among European scientists on general topics with a more spontaneous (less financially incentivated) mechanism.

'Spontaneous' or promoted, but still bottom-up, *networking mechanisms* are not limited to basic science. Some of the selected topics are within the *applied research* domain and address issues of direct relevance for society. One of the first public policy to promote networking/ cooperation on socially relevant issues was the NATO's Challenge to the Modern Society Committee programme. Some of the ESF Networks are devoted to social objectives as well.

The more public money are injected in the *science network mechanisms*, the greater is the temptation to '*plan*' top-down by attracting scientists attention on objectives of social interest. It is a question of basic concern - in trying to define S&T policy focused on the globalization issues - to understand whether or not a "lamarckian" top-down approach (i.e. the needs change the choice of research topics to produce solu-

tions that satisfy the needs) can be developed.

Unfortunately, the results of explicit efforts of top-down planning the basic or applied research are not exciting. Take the **Eureka** programme. It started very ambitiously as a mean to respond to objectives of social relevance and it ended as a general tool to favour the cooperation among industries on research themes proposed by research partners.

A different but interesting case is the **Human Frontier Program** proposed by Japan that calls for research cooperation around a spelled-out research agenda. The program does not foresee a central flow of money to support scientists work, assuming that interested scientists use their locally available resources and their freedom to chose the research topics. What has been the fate of the program? So far, it seems that it has not met the expectations, that is the development of a strong network of cooperating scientists. Why?

Another attempt from Japan to call for international cooperation, **The Intelligent Manufacturing System**, failed due to suspects of competitive industrial interests.

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? Even if so, we have still to answer the question whether or not there is a way to accelerate such "natural" mechanisms.

3.1.2 Influencing scientists networking and research agendas

To this effect, it is important to better understand the *motivations of scientists and the mechanism influencing them*. Each scientist is very sensible to the scientific community selection mechanism. Furthermore, scientists and the scientific community are very sensible to scientific leadership.

By opening a new science fields, **science leaders**, perform a very practical role with respect to the other less genial scientists. They break down the scientific challenges into small pieces that can be approached successfully by a young or an average scientist. Implicitly, the leader perform an important organization task in science: the definition of the "work breakdown structure" to achieve the general objective of advancement of the concerned part of the science frontier. A "small" piece of research performed by a 'small' scientist becomes useful because it contributes a limited but concrete part to the total research objective. Moreover, the task of the 'scientific community' of evaluating individual scientists' contributions (which is very important for scientists' career) is facilitated and scientists' risk is reduced.

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. The lack of clear research leadership (or at least of a very clear definition of research scopes broken down into little but significant research tasks) might explain the failure of programs such as the Human Frontier, or, on the contrary, its existence be at the base of the success of programs such as the Human Genome.

Can *the leadership* on selected research topics *be organized*? At least it is possible to use the prestige of scientists and scientific schools in the North to develop science network which include scientists and school of the South?

The policies for this concern might be ²⁴:

- to call leader scientists to define research agenda which bridge their scientific interests with social needs,
- to help the enlargement of existing research networks or clusters, to scientists living in LDCs,
- to call the scientific community to contribute the generation of a portfolio of ideas on research problems relevant for the globality issues.

3.2 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 (vs 'local' products responding to local needs and peculiarities);
- the world-wide diffusion of manufacturing process and production organization such as FMS, JIT, etc. (vs manufacturing processes which are more sensitive to the peculiarities of local production factors and to the scale of local markets);
- the development of 'global enterprises such as the TNC's (vs those oriented on domestic production/markets);
- the *volatility* of technology, i.e. an increased accessibility of the technological 'endowment' by entrepreneurs wherever their base of operation might be (against more 'appropriable' technology);
- the ability to design and manufacture products using '*generic*' technology (vs more '*specific*'/'*localized*' technology).

The statement that there is a trend towards the "globalization of technology" is therefore not a simple one and requires clarification. The different aspects of globalization might not necessarily be complementary or compatible reciprocally. To exemplify, TNC's might develop through the exploitation of very "localized" technological innovation. Moreover, experts have contrasting views of the reality of the S&T globalization phenomenon.

3.2.1 The development of networked enterprises

The interest of recent analysis ²⁵ focus prevalently on the phenomenon of TNCs development. It underlines the following characteristics aspects

- the *emergence of "global networks"* of company operations, (with the word "network" one stresses the fact that no single "nodes" play the role of permanent "centre" of the network);
- the optimization of the production process by exploiting the local advantages the nodes of the network through a "*global switching*" dynamic (location of the dif-

²⁴Because of the importance of the issues, we have - in the list of R&D programmes described in Part V - pinpointed two proposals that aims at increasing global cooperation between scientists (V.3.5.2 *Developing a Commonwealth of Science for the enlarged European region*, and V.3.5.4 *Globalization of Science and globalization issues*).

²⁵See FAST Prospective Dossier n. 2 *Globalization of Europe and Technology*

ferent production phases/activities at different places) which includes manufacturing functions and as well as R&D, design, marketing functions ("vertical" inter-functions, and "horizontal" intra-function global switching);

- the adoption of a flexible strategy which includes "*global focusing*" (i.e. the concentration, if necessary, of the entire production process of a certain product line in a node of the network) when it appears the best .

The network concept is not necessarily a 'global' (world-wide) one. An enterprise might develop a network national, regional or continental strategy. As a matter of fact, the evidence relative to the emergence of TNC's indicates that the process take place in the *triadic* regions.

An ideal "network" strategy is possible if there are not spatial barriers among the nodes of the network. A company that organizes along a network scheme needs an homogeneity of the rules of the game on the network. Even more important is the possibility production factors to freely move along the network (freedom to decide where to locate facilities for different production phases).

One basic question of concern with respect to globalization is whether or not it is possible to forecast a path of networks development from more restrained spatial extension to world-wide one. The possibility that this trend takes place depends on the increase of enterprise bargaining power that the network homogeneization brings about.

The analysis of the cases of industrial '*global enterprise networking*' tends to underline a *typical trajectory* in the evolution of the network organization. This trajectory has many similarities with the criticized international product cycle (which therefore might apply to single companies, even if it fails to explain satisfactorily the aggregated picture).

At the beginning of the networking process the previously home-based enterprise starts by investing abroad for manufacturing plants (let's us suppose to serve only local markets); then it has to develop technical services to support local production facilities and local markets; due to the technological changes that involve also the factories abroad and to the increase of local market requirements, then the enterprise is forced to develop local more sophisticated quality control techniques; then, to better exploit local production factors and better serve local markets, local plants to acquire the ability to modify products and production processes; finally, the locally developed capabilities reach a point at which local management ask for a broader "product mandate" (to serve not only the local but also export markets). At this point the local activity becomes a real "node" of the network and it can pretend to step in the network strategy of the enterprise.

In other cases the trajectory might jump directly on establishing foreign production activities to serve the export markets. In such cases, the requirements for local "sophisticated" services for the production starts at the very beginning of the operations. With the development of the operation itself the requirements grow further for the same reasons explained above (i.e. to follow technology and market change). As a result, there is an overall effect of context modification, which include TT.

The conclusions that can be made from the analysis of the networking phenomenon, is that *the technological change "travel" through out the company network*. This af-

fects company strategy, organization including the decisions concerning where to locate the different production activities and functions (R&D, design, manufacturing, sales, technical services and assistance). Because of the technological change, the "focus" of the activity might have to be displaced from one node of the network to another.

The more the network reaches a global scale, the more it is sensible to other phenomena that characterize the globalization of technology. To give an example, company strategy might be better placed to choose between different production options (and to change the decision over time), such as the "make vs buy" alternative for many of the material inputs and services that enter into the transformation process, or the "global vs multiple local sourcing" alternative. New technologies, such as the 'flexible manufacturing systems can applied all over the network and therefore the company has the option to choose between "global standard" products or more flexible ones to meet local market needs.

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 in other nodes).

3.2.2 Public S&T policies and technology networking

The appearance of enterprise networks requires a revision of R&D policies, both internal and external (public policy) to enterprise.

In fact, the basic assumption that production factors freely flow along the network, represents a sort of "decoupling" of the network with 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 the policies.

Should therefore the phenomenon of enterprise networking be considered a positive one or not by public decision-makers? The answer is likely to be different according to the "dimensional" level of public policies (local, national, regional, world wide).

In principle, with respect to the globalization challenges the development of networked enterprises could be considered a convenient organizational responses, since it permits to better exploit the available resources to meet the enterprise's objectives. As such, *the network organization frame could be mutuated also by non-enterprises decision-makers dealing with globalization challenges.* The fact that networking has diffused in the scientific field might support the hypothesis.

The question however remains whether an enterprise's network - while optimizing the enterprises performance - might be in contrast or not with public objectives and expectation. The question deserves a deeper analysis. Here we will only superficially touch on the reasons and the conditions necessary to positively evaluate the development of enterprise networks with respect to the general problem of exploiting S&T to deal with the globalization issue.

A prerequisite to exploit the potentiality of S&T is the availability of S&T at the level at which the problem pertains (local, national, regional, world-wide). A major contribution to the globality challenges will be given by the ability to keep and resolve the problems at their proper level. This will be possible, the more technology

will "globalize" in one of the sense listed before, e.g., that of global "volatility" (S&T is within the reach of every one that needs to use it, according to his own level of action). Helping diffusing technology (TT) is therefore an important prerequisite objective.

The more the technology becomes *generic*, the easier is to reach this objective. However, many of the competitive advantages of enterprises are based on the exploitation of *localized* (specific) technological changes. There is therefore a contradiction between public policies and enterprise strategies. However, the contrast might be less than it appears, especially as a consequence of enterprises operation in technology diffusion (TT).

In fact, as *enterprises* (operating in all sectors in primary, secondary, tertiary) are "*carriers*" of *technology*, they have *direct and indirect important effects on TT*. The location production activities (one or more production functions and not only the manufacturing one) in certain sites, changes the local context (as is well known by public local authorities trying to attract enterprises). TT is an example of context change (at different extent according to the type of activity and the liaisons with local suppliers).

These effects take place also in the case of networked enterprises. In such context, TT acquires also a spatial dimension as different nodes of the network are involved in TT. At the end of the day, the true network operation is bound to have the effect to push the "homogenization" of the territory around the nodes.

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. First of all the level of *public actors* changes. In the former case, it includes local, national, regional and world levels. 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 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*. In other terms, local public policies aiming to attract enterprise activities might take advantage of the concept of the node in its comprehensive and dynamic meaning: e.g., incentives may be designed to attract not only manufacturing activities but also the other production functions, including R&D.

Actually, accepting the concept of free "mobility" of production factors along the network, might bring about a positive dynamic effect on local context which could exploit all the potential advantage of local factors. 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. To develop consistent policies at the different levels of social organization (local, national, regional, etc.), is the more possible the more there are explicit societal organizations at every level. There is here a great challenge and opportunity for the

EC to favor the development of the enterprise network concept within the boundaries of the European "region".

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?*

Following the logic of network operations, *the public intervention might find new scope in the fact that the network operations actually increase the strategic alternatives the company may consider.*

One way to obtain this effect is to help enterprises to make the choice in one or the other direction of each alternatives. E.g., one could facilitate the decision to increase the "buy" with respect to the "make" or to choose the multiple sourcing with respect to the global one.

Complementary policies of intervention on the environmental context in order to facilitate the transformation of a local company activity into a real node of a network should be very useful. Mostly important are the interventions on the communication and transport infrastructure.

Another far reaching policy intervention (in line with the technological trends toward more flexible production systems) is to promote the development of products which are more flexible with relatively to local market needs.

3.2.3 Globalization and 'generic' vs 'specific' technology

Even more important 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 potentialities. 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.²⁶ A product or a production process can be seen as a complex system made of subsystems, components and materials. "Appropriability" might concern all level: the entire system, the subsystems, the components or materials. An enterprise might tend to keep the maximum degree of appropriability. by considering the products and the production process as a single system. More often, however, the real specific advantage of appropriability occurs more at the subsystems or components level. 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. As a matter of fact this happens in several fields, as in the case of the use of vehicle engines to produce remote electric generators.

²⁶The issue is developed with specific policy proposals in the accompanying FAST paper, C. Antonelli et al, *Revisiting Technological Transfer.*

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

In other words, the interactions of public bodies with global networked enterprises might favour the development of "local technologies" (products/processes) dealing with local products/markets. The impulse to develop local technologies (and therefore to develop new local entrepreneurial activities) might well be less in contrast with the development of "global technologies" from what appears at first glance. *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" tend to disappear by shifting the concept of 'globality' from the product/process systems to their components.*

In conclusion the different aspects (listed at the beginning of this section) of the "globalization of technology" interact among themselves. One could look for a leverage effect on such interactions by developing proper policies that exploit all the different aspects of globalization and by using the interaction between public policies and enterprise strategies as a powerful tool of change.

3.2.4 The neutrality of S&T and the prospects for LDC's to exploit S&T

The above remarks on the globalization of technology should also help to *clear the issue of technology and LDC's*. The more the **globalization of technology** increases the availability of S&T to entrepreneurs world-wide, (increase the "volatility" and the "genericity" of S&T), the more LDC may exploit S&T potentialities.

With respect to the differential gap in problem-solving in the North and South S&T is intrinsically neutral. 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. In turn, this depends on the specific problems to which S&T has been addressed up to now, and on the priority topics in the basic research agenda of the scientific community. Here are the roots of the North-South gap in using S&T tools to respond to the respective challenges.

However, no matter which specific courses for S&T applications are followed, there is a continuous fall-out from 'specific' S&T projects that feeds the knowledge (scientific and technological) base. And this base is potentially applicable to any problems.

The different aspects of "globalization of technology" - including the networking of production activities - could help (via appropriate public policies) to shift from a **neutral** S&T to a **benign** S&T with respect to LDCs' challenges.