Centre for Southern European and Mediterranean Studies
Research Report No. 2/1992

SCIENCE AND TECHNOLOGY COOPERATION BETWEEN EUROPE AND THE ARAB WORLD

Interdisciplinary studies of innovation for introductory paths of an innovative North-South cooperation in the Mediterranean basin

Jean-Baptiste Meyer - Kapil Raj
with the collaboration of Riccardo Bocco

MARGINALIZATION, SPECIALIZATION
AND COOPERATION
IN THE MEDITERRANEAN REGION
FAST- PROGRAMME 1991-1992
CNEL 1991

ROSKILDE UNIVERSITY
POSTBOX 260
DK-4000 ROSKILDE

ISSN 0109-4343

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Interdisciplinary studies of innovation for introductory paths of an innovative North-South cooperation in the Mediterranean basin

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INTRODUCTION

Are scientific and technological innovation crucial for international development ? This issue seems less controversial than it used to be. Science and technology inputs in socio-economic development is highly valued by Developing Countries. Arab states do express the same feeling. Consequently, sharing of knowledge and technology transfer among the latter and between them and Western countries, especially from the EEC, should be fostered[1]. However, some voices may be heard expressing legitimate doubts on the actual conditions of such transfers. According to these views, the EEC objective would be its own technological development in order to be competitive on the global market in the year 2000 against Japan and the United States. Accordingly, this current trend is likely to broaden the gap between the two banks of the Mediterranean sea because it would not be in the EEC interest to see an autonomous technological sphere emerge on his back[2]. Avoiding such a situation is precisely what our network is for[3].

The following presentation is a contribution to a new approach which would suggest alternative ways for an international development between the EEC and Arab countries. It is organised in four parts:

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[1] cf Technology policies for development and selected issues for action; Proceedings of a seminar organised by the Islamic Development Bank and UNCTAD (United Nations Conference on Trade and Development); United Nations, New York 1988

[2] cf especially I. EL-ZAIM, Technology and North-South technological relationship (with reference to the Arab region), in Technologie et Dévelopement dans les pays Arabes; Institut des Pays en Développement, Université catholique de Louvain; CERMAC, cahier 40, 1986

[3] cf European network on Regional Cooperation and Technological Innovation, Science and Technology in the Process of Globalization of the Economy; National Council of Economy and Labour (Rome), Center for Southern European and Mediterranean Studies (Roskilde); Rome, January 1991

1- A first part in which S&T is put in perspective within the Arab world development

2- A suggestive description of the framework in which current scientific institutions operate on the other side of the Mediterranean sea.

3- An analysis of social dynamics at works in S&T and development spheres

4- The significance for the "inter-banks" cooperation as well as for socio-economic development and suggestions for a new approach.

The authors of this paper do think that S&T transfers are today very much tied to power relationships. They are crucial stakes in the global changes of the end of this millenium. Neither is there any doubt that the shift in East-West relations affects the North-South ones. Technical and scientific cooperation are well suited to bridge the gap in these relations. As the Gulf War revealed at a global scale, technology, ideology and social organisations are highly intertwined and their combinations may be explosive, especially in the Arab world. Building bridges over the Meditteranean sea is thus today particularly relevant.

I - PAST AND PRESENT, S&T PRODUCTION AND TRANSFER IN PERSPECTIVE

Innovation studies, principally history and sociology of science as well as economics of technical change, have recently undergone major advances. They bring a new light about the relationship between socio-economic developments and scientific-technological realisations.

I-1. The lessons of history

Mediterranea is not a frontier but a space of exchanges[4]. True for the ancient times, the citation is also valid for the medieval as well as modern ones. In the middle ages, eventhough there was confrontation between a rising Europe under Christianity and the Arab empires under Islamic rule, material and intellectual flows generated strong developments in both societies. At these times, the technology transfer adopted a South-North direction. A highly

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[4] F. BRAUDEL, La Méditerrannée, Flammarion, Paris, 1985

symbolic example is the astrolabe: invented by Arab scientists and adopted by iberic navigators, it allowed the fabulous political and commercial expansion of the european society. This was made possible by the successful efforts of the arabic scientists to create an instrument which could be available not only for local use but also under all latitudes. The search for universal application through scientific astronomical rules is at the core of this process[5].

In the linkage between sciences, technology and society lies the success of Islamic innovation and its astounding assimilation by foreign actors. "More than the Greeks, the Romans or the Byzantines, the Arabs recognized technology as a legitimate part of science"[6]. And technology use and improvement was itself deeply rooted in society. Artisans, organised in professionnal guilds, were proper vectors for dissemination of technics derived from techno-sciences experiments in textiles, construction, chemicals, etc... There was even an institutionalized quality control of their crafts. The *muhtasib*, a government official ensuring conformity with public morals and religious beliefs, checked weights and measures and dealt with the problems related to scale and measurements[7] . Social categories, religious status, technical devices and scientific rules were intertwined in a highly efficient manner. This is no different from socio-technic modern configurations except that tasks, then incumbent to religious characters, would be today under the responsibility of civil servants. This picture of the flourishing scientific and technological Islamic civilisation leads to more realistic considerations about development and technological innovation. Economic progress and technical change may not be exclusively analysed on a european standard such as in a

[5] on the relationship between scientific instrumentation and inscription, universal representation and the discovery of new worlds, see La Pérouse's case study: B. LATOUR, Comment redistribuer le grand partage?, Revue de Synthèse, No 110; Avril-Juin1983

[6] from: A.Y. AL HASSAN, D.R. HILL; Islamic technology, an illustrated history; Cambridge University Press, 1986; p 263

[7] id.

weberian[8] and schumpeterian[9] approach. Historically, western Christian ideology and individual entrepreneurship do not appear to be the panacea for scientific and technico-economic development. Furthermore, as shown in the third part of this paper, there is a positive link between Islamism and techno-scientific development in the contemporean Arab society.

What history suggests is that social, cultural and religious differences are not absolute obstacles to constructive S&T exchanges between us and the Arab countries. There has been a shift of the epicenter of technical & scientific production from the south to the north. But pervasive innovations in both directions across the Mediterranea show the interrelatedness of respective developments between both geopolitical blocks. Such developments do not systematically depend on, or generate, assymetric relationships; they may instead originate from, and foster, some kind of unity in specific areas. In the agricultural sector, this is the case of the "Mediterranean plough" which has been diffused and used by European as well as Arab peasants in the all basin for centuries[10] .

These transfers are everything but automatic. They indeed require a strong effort to create conditions for the adoption of an exogeneous innovation which will, after adaptation, develop a society's resources. This is true for today's petrochemical industry as it has been for the plough before. A successful adoption is derived from a convergence of actors which have learnt to appraise and analyse the potential benefits of an innovation in a collective manner through a socio-technic negociation process[11] .

I-2. Science, technology and development in the Arab world

[8] M. WEBER, L'éthique protestante et l'esprit du capitalisme, Paris, Plon 1969

[9] J. SCHUMPETER, Capitalisme, socialisme et démocratie, 1942

[10] A.Y. AL HASSAN, D.R. HILL; op cit and A.G. HAUDRICOURT, L'homme et la charrue à travers le monde, Gallimard, Paris 1955-1986.

[11] cf especially M.AKRICH, M.CALLON, B.LATOUR, A quoi tient le succès des innovations?, Annales des Mines ; Gérer et Comprendre, Nos 11-12, Paris,1988

The Arab world is characterized by a huge diversity in the conditions in which S&T may develop. Economic resources, population size, social organization, scientific institutional framework may greatly vary from one country to another. Development strategies are thus diverse and therefore technical as well as scientific stakes are also very different.

As mentionned above, science and technology are perceived as highly valuable development factors by all Arab countries like most LDCs. Consequently, construction of S&T capabilities is a major objective of their public planning (cf part II). However, the success of such a construction depends also very much on their state of development. The relationship of S&T with development is thus paradoxical and complex: accordingly, S&T inputs are required for development while the latter induces S&T advances. For example, not surprisingly, the global scientific production of LDCs in mainstream sciences is indeed quite low[12] . This weakness may not describe the complete situation of their activities in this field because a lot of it escape the scientometric indicators used to measure it. However, it partly explains the dependence of LDCs on foreign collaborations for techno-scientific developments. This is the case of Arab countries for which knowledge and technology transfers from western countries are thus crucial. Among the latter, the EEC which is a major trading partner of the Arab world is especially important.

Arab states heavily rely on western technical cooperation for their own development strategies. However, at the same time and through this cooperation, they devote a significant part of their efforts to build autonomous S&T capabilities. Presently emerging scientific communities in these countries witness to this phenomenon[13] . The Arab world is, indeed, provided with a techno-scientific institutional framework (cf part II). Public research institutes have been created; national S&T strategies have been designed; technology transfer guidelines have been set up. Of course, such realisations differs from one state to another, but some have become quite visible (in Morocco, Algeria or Egypt, for example). Moreover, this general trend toward the techno-scientific build up in the Arab world may be noticed by the involvement of muslim institutions, like the Islamic Development Bank and the Islamic Foundation for Science, Technology and Development, in S&T related issues[14] .

These are actual and potential partners for an efficient transfer of knowledge and technology between Europe and Arab countries. The existence of local, domestic capabilities is decisive for a country's ability to absorb foreign technological inputs[15] . Arab countries are implementing "learning by doing"[16] approaches, with the assimilation of western innovations through their own structures. With this intermediation, the will is to go beyond simple turn key transfers and to progressively get a higher bargaining power in negociation process of technological exchanges. This purpose may not always be successful. Some scholars present skeptical views about the actual capacity of islamic countries to absorb technological capability. They consider that the incremental speed of innovation in western countries leaves no chance for others to catch up with their level[17] . Even procedures facilitating a "learning by doing" approach, such as joint ventures between firms, might not eliminate assymetric relationships[18] .

In fact, a major concern of economic development through scientific and technical innovation

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[12] cf J. GAILLARD, La science du Tiers monde est-elle visible ?; La Recherche, No 210, Mai 89 pp 636-40 and R.ARVANITIS, J.GAILLARD eds, Science Indicators for Developing Countries; Proceedings of the UNESCO's conference on Science indicators for Developing Countries, October 1990; ORSTOM, Paris, forthcoming

[13] cf R.WAAST, "L'émergence des communautés scientifiques", in Colloque ALFONSO, ORSTOM, Paris, 1991.

[14] UNCTAD, op cit.

[15] Adilson de OLIVEIRA, Energy technology in developing countries, Science and Public Policy, vol 18, No 3 June 1991

[16] for the "learning by doing" approach to innovation in the Arab world, see M.K. ARROW as well as L.K. MYTELKA cited by A.R. YOUSEF, in UNCTAD, op cit.

[17] Technologie et Dévelopement dans les pays Arabes, op cit

[18] cf B.KHADER, Le transfert de technologie vers les pays arabes, Limites et possibilités; in Technologie et Dévelopement dans les pays Arabes, op cit

in LDCs is probably the weak link between the research and the industrial (or/and the agricultural) sectors[19] . Recent approaches, especially derived from studies on EEC programmes, clearly show the crucial role played by actors connected in "techno-economic networks" in the innovation process[20] . Without such heterogenous networks mixing market signals with basic researches, the best efforts led by disconnected spheres are useless.

These networks are at an embryonic stage in most Arab countries. However, there exists relevant actors on which public policy may rely to develop them. The following part is an empirical study giving an idea of the characteristics of such potential or actual partners.

II - A VIEW OF THE S&T SOCIO-INSTITUTIONAL FRAMEWORK IN THE ARAB WORLD

II-1. An original study of the Arab S&T context [21]

When in the 1960's science policy analysts and planners began to devote their attention to the development of science in the then newly-independent countries of what is now called the South, their primary concern was in institution building. This amounted in the main to providing for material and human resources. And, today, most countries can boast of possessing a scientific and technological infrastructure measurable in terms of scientific and technological institutions, qualified manpower, and a science and technology planning bureaucracy. However, about thirty years on into this enterprise, we can now begin to ask ourselves what these investments have led to - in other words, how S&T institutions started in the 1960's and 1970's are faring.

In the context of the developing countries, the object would then be to unearth the strategies an institution adopts in order to legitimate itself in its environment. For, it must be remembered that almost all the S&T institutions set up in the developing world have been established by the state and depend heavily upon the latter for funds and legitimacy. However, for an institution, and through it for the community that mans it, to survive over a long period, it has to widen its network of support to other sections of the broader society. And while in the industrialized countries science has succeeded in finding an anchorage inside society, to become what Alain Touraine has identified as the hub of change where developments are shaped and society is transformed[22], this is not always the case in the developing world. In the words of Edward Shils, the doyen of science-policy studies, the issue is one of "the establishment of beliefs and orientations that heighten and maintain sensibilities and motivations and that prompt the selection of important and appropriate problems for investigation and suggest the approach toward them in ways that permit their fruitful solution. Countries in which science is well established may take this for granted. All they need do is see that there is a flow of young students into fields needing investigation

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[19] cf R.ARVANITIS, De la recherche au développement, Les politiques et pratiques professionnelles de la recherche appliquée au Vénézuela; thèse de doctorat en sociologie; Université Paris VII; 1990

[20] cf especially P.LAREDO, M. CALLON, L'impact des programmes communautaires de recherche sur le tissu scientifique et technique français, Paris, La Documentatin française, 1990

[21] The study that follows grew out of a demand formulated by the Arab countries that UNESCO contribute to the improvement of the management of scientific and technological institutions of the region. It was carried out between March and October 1988. The results were presented internally to the Division of Science and Technology Policies in February 1990.

[22] A. Touraine, *Production de la société* (Paris: Le Seuil, 1973)

and into institutions in which work is being done in those fields[23]." But in countries where contemporary scientific institutions with their concomitant practices have only recently been established, ancient research traditions, as in the case of the Arab region, notwithstanding, all the groundwork for the social legitimation of modern S&T activity has to be done *ab initio*. This process is thus also linked to the broader one of the emergence and status of scientific communities in the developing countries (cf part III). One of the ways of measuring the degree of legitimation is in function of the capacity of a given institution's ability to take to other types of S&T activity than the one it started out performing. Let us explain: S&T activities can be classified under five general headings[1]:

1. Production of scientific knowledge and/or instruments and/or techniques and/or services for the production of such knowledge;
2. Participation in industrial research;
3. S&T education and/or training;
4. Improvement of the public image and understanding of science and technology;
5. Participation in State-sponsored research and development projects.

Now, scientific and technological institutions carry out at least one of these activities. The nature of its legitimation (or social anchorage) strategy can then be gauged from the combination of different types of S&T activity undertaken by the institution in question as also from the change in nature of the combination over time. This type of enquiry, then, is

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23 E. Shils, "Introduction" in E. Shils, ed., *Criteria for Scientific Development: Public Policy and National Goals* (Cambridge, Mass.: MIT Press, 1968): xiii-xiv

1. See M. Callon, *La science et ses réseaux* (Paris: La Découverte, 1988); and M. Callon, R. Chabbal & P. Laredo, "L'évaluation des programmes technologiques: enjeux et organisation", in J. de Bandt & D. Foray, eds., *Lévaluation économique de la recherche et du changement technique* (Paris: Éditions du CNRS, 1991): forthcoming

not normative in that it does not seek to transfer recipes from the industrialized world to the developing one, but rather, has as its starting point the idea that each socio-cultural context provides the basis for specific strategies and seeks to bring them to light. This approach has the two-fold advantage of providing a picture of the institutions' alliance patterns to decision-makers in each institution and region concerned, as well as of providing models for other institutions in the area that are in the process of being set up .

Instead of trying to make an exhaustive study of all the institutions of the whole Arab region, we opted to concentrate on those institutions which had already established a reputation for themselves in the region and outside. In this way, one can hope to identify strategies that account for the success of these institutions within their own context, without having to resort to the common practice of imposing norms from the industrialized world. Concretely, we did this by consulting Arab and non-Arab colleagues from the Science Sector of Unesco, working scientists in France, as well as a SPRU study[24] . The result was a motley crowd of 75 scientific and technological teaching, research and development centres spread across 17 countries. We selected 29 significant scientific and technological institutions for the following analysis.

The approach then consists in appraising the manner in which a group of institutions, previously selected in function of their degree of recognition and renown, interact with the prevailing socio-cultural context. In other words, the problem lies in determining the extent to which the given institutions and contexts affect and transform each other[25] .

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24 R.M.BELL, ed, The acquisition of imported technology for industrial development: problems of strategy management in the Arab region; Brighton; SPRU 1985; mimeo

25 The underlying idea here is that, following Malinowski, cultural change can only take place through some means of organized behaviour. According to him, "The invention of a new

The method then lies in identifying a series of indicators that would help grasp and describe the strategy and impact of our set of institutions. As a first step, it is indispensable to situate our group of institutions inside the socio-institutional context of the Arab region and then to proceed to check against a list of fundamental characteristics of a scientific and technological (S&T) institution *per se* in order to ascertain how each characteristic in the given set of institutions relates to the other characteristics as well as to their socio-institutional environment.

An S&T institution has 5 principal characteristics: objectives, means, outputs, networks and organizational features aimed at providing itself new objectives, means and a capacity to shape the outside world.

The effectiveness of an institution is then a measure of the adequacy of the ends with respect to the means and of the articulation between the different characteristics outlined above.

With the abovementioned as working hypotheses, we formulated a questionnaire addressed to the heads of the selected. Once the information was gathered, we computer-processed the questionnaires in order to help provide typical profiles of institutional strategies through factor analysis.

II-2. Strengths and weaknesses of S&T in Arab Countries

technological device, the discovery of a new principle, or formulation of a new idea, a religious revelation or a moral or aesthetic movement, remain culturally irrelevant unless and until they become translated into an organized set of cooperative activities." B. Malinowski, *A Scientific Theory of Culture and Other Essays* (New York: Oxford University Press, 1960) p. 43

a) General results

Legal status of institutions : Almost all the selected institutions are either State owned or else were at least set up by the State, or with substantial state support. This means that legitimacy from the side of the State is for most of them, though not necessarily all, an established fact. An additional sign of a strong relationship with the State is brought to the fore in the table below which shows that almost all the institutions concerned participate very actively in these types of committees and have a fairly large diversity of interactions at the state level. This provides a good indication of their implication in defining and implementing certain kinds of strategic scientific and technological activity which can generally only be guaranteed by the State and suggests strong alliances between the scientific, technological and bureaucratic elites.

Participation in national scientific and technological committees

Type of Committee :	Standards	University	Public	R&D	Industrial	Defence	*Total*
Abu Dhabi		1			1		*1*
Algeria	2	2	3		2	2	*3*
Bahrein	1	1			1		*1*
Egypt	1	1	2		2		*5*
Iraq	1		1				*1*
Jordan	2	1	1		2	1	*2*
Kuwait		1	1				*1*
Libya	2	1	2				*2*
Morocco	3	3	3		2	1	*3*

Qatar	1	1		2		1
Saudi Arabia	1	1	3	1	2	3
Sudan	1		2	1		2
Tunisia	1	1	2			2
Yemen Arab Republic	1		1	1		1
South Yemen		1				1
Total	*17*	*16*	*21*	*15*	*6*	*29*

As shown in the next table, the vast majority of institutions had at least two of the abovementioned five types of S&T activities. Although this is clear evidence that there is a diversification of objectives, it is not clear from this table alone as to whether it is for purely internal institutional reasons or in order to enroll external partners. It is precisely in order to determine the nature of the institutional strategies involved, that we need tools for multivariant analysis, which we shall come to in the next section of the study.

Activity

	Sc. Knowledge	Indust.	Education	Popularisation	*Total*
Abu Dhabi		1	1		1
Algeria		3	2		3
Bahrein			1	1	1
Egypt	2	5	4	2	5
Iraq	1	1	1	1	1
Jordan	1	2	1		2
Kuwait	1				1
Libya	2	2	1	2	2
Morocco	3	3	3	2	3
Qatar		1			1
Saudi Arabia	3	3	3	3	3
Sudan	2	2	2	2	2
Tunisia	1	1	2	1	2
Yemen Arab Republic		1	1		1

South Yemen	1					1
Total	*17*	*26*	*23*		*15*	*29*

The annual expenditure for the selected institutions (next table) is extremely disparate between Sudan at US$381,000 for 2 institutions at one end of the spectrum, and Saudi Arabia with an annual budget of US$ 212,220,000 for three establishments at the other end. There is indeed a correlation between the financial wealth as well as the size of a country and its investment in R&D. Nonetheless, this table may show that the financial situation does not completely determine the level of investment. Despite a huge indebtedness, Egypt devote a significant budget to its scientific and technological activities. These investments are also very much related to the level of foreign aid. In the case of Egypt, the contribution of USAID is indeed quite important.

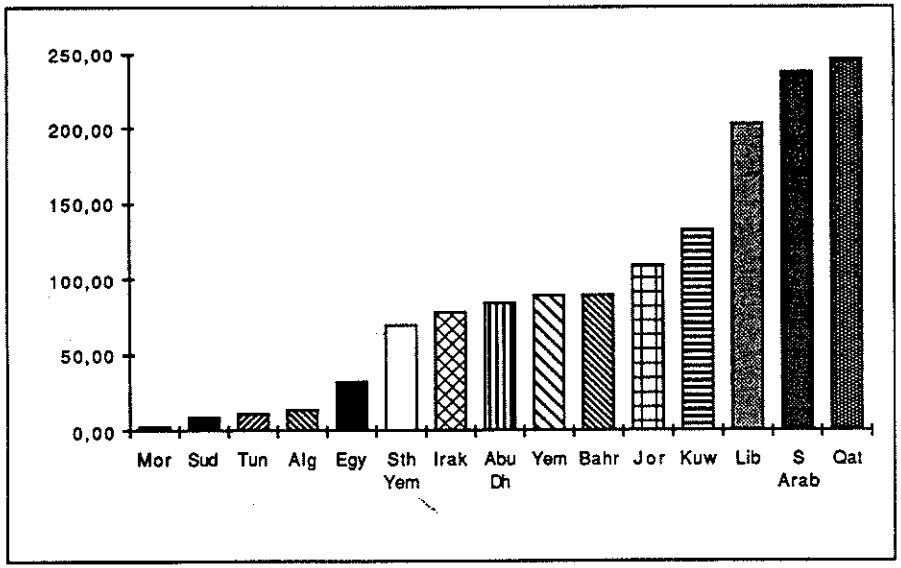
However, in order to get a real appreciation of the diversity and inequality in the region, it is much more meaningful to relate the previous figures to the number of scientists and engineers in each country. We can then represent the expenditure per scientist in each country, which gives us the histogramme below.

Annual expenditure

	Annual Budget in US $
Abu Dhabi	1,362,000
Algeria	4,217,000
Bahrein	5,600,000
Egypt	45,266,000
Iraq	4,613,000
Jordan	18,935,000
Kuwait	32,300,000

Libya	15,500,000
Morocco	1,876,000
Qatar	4,700,000
Saudi Arabia	212,220,000
Sudan	381,000
Tunisia	2,400,000
Yemen Arab Republic	900,000
South Yemen	1,960,000

Country-wise Expenditure per Researcher



From this figure, we may infer that, among Arab countries, those of the Mediterranean basin (except Lybia) have a lower level of average expenditures per researcher. Comparing it with the previous table which showed that their budget was not that low, we can easily deduce that the number of researchers is relatively high in these countries. They have, indeed,

already significant S&T staff on which to divide limited resources. Moreover, the strength and performance of S&T communities in the Arab world are not strictly related to the size of the budget; their dynamics depends, indeed on many factors [26] . However, paucity of financial resources is something that european should also look upon as it may hamper further qualitative development of S&T capabilities in such countries.

b) The correspondence analysis

Methodology: Correspondence analysis[27] consists in representing graphically through mappings the networks of relations between variables characterizing the institutions. Each type is defined by a few institutions. Each institution is represented by a point on the graph.

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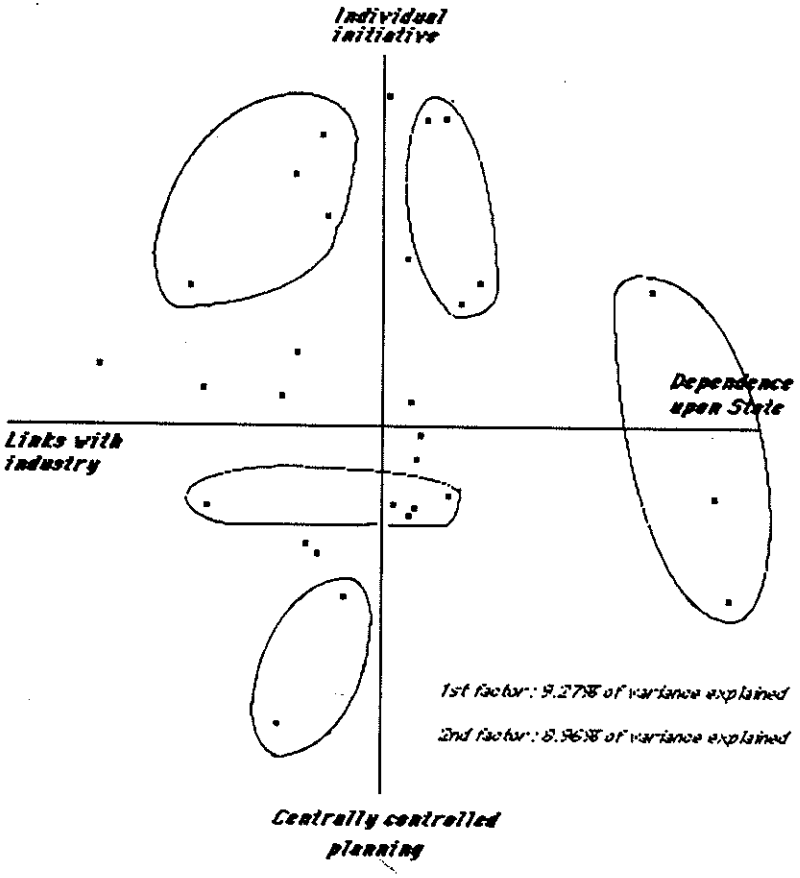
[26] cf R. WAAST, op cit.

[27] J.P. Benzècri, *L'analyse des données*, 2 vols. Vol 1: *La taxonomie*; Vol 2: *L'analyse des correspondances* (Paris: Dunod, 1973); See also M. Hill, "Correspondence Analysis: A Neglected Multivariate Method", *Journal of Applied Statistics*, **23** (1974): 340-354; and J.P. Fenelon, *Qu'est-ce que l'analyse des données?* (Paris: Lefenon, 1981)



Now, although at first sight, the institutions vary greatly in size, budget, type of activity and socio-economic environment, the groupings obtained by means of the correspondence analysis allow us to determine general profiles based on certain common strategies. We

were thus able to identify five distinct groups.

Type 1 (on the right side of the graph): These institutions are characterized by a very strong dependence on the State, with few links with other scientific and technological sectors. However, through the State, they are, though not very strongly, linked to economic-developmental activities. The ratio of engineers to scientists in this category is low: of the order of 1:3.5. The population consists of 3 establishments, a figure which tends to show that although, as mentioned above, almost all the institutions studied were established either by the State or with significant State aid, the vast majority find other sources for their continued existence and legitimation.

Type 2 (in the middle of the graph): These institutions, in contradistinction to the previous ones, have developed strong links with the industrial sector, either through substantial industrial contracts or by establishing institutionalized relationships at the planning or marketing level with industrial networks. It must be said immediately that the industries involved are not necessarily private - quite to the contrary, they are large State-run heavy-industrial complexes - but have an entrepreneurial logic. In this category we find applied research institutions which though set up by the State, have, for one reason or another, had subsequently to fend for themselves. The ratio of engineers to scientists here is, not surprisingly, much higher: 1.2:1. These institutions also show a certain degree of coherence in their planning and output.

Type 3 (at the bottom): Here we find those institutions which have a centrally controlled long- and short-term planning system. In this category are situated the research sections of the heavy-industrial sector. Thus we see that they also have an organised effort to market the results of their research. The set is composed of 2 members. Unfortunately, owing to the small size of the sample, little more can be said of the similarities between the establishments concerned, except perhaps to highlight an important difference from Type-2

institutions: contrary to the latter type, in-house industrial research in the institutions considered in this category does not seem to link up with other research and development establishments.

Type 4 (upper left): This category defines itself as the antipode of type 3, in that the dynamic is insured by the personal initiative of the S&T staff and the legitimacy of the institutions is drawn from international or "mainstream", and in particular, West European and North American, science. This can be made out from the closeness of the variables for North America and the European Economic Community. This category is composed mainly of engineering schools, which also have a link, though not always very strong, with industry. We were able to discern 5 such institutions. The ratio of engineers to scientists in this profile is not a determinant feature as it is very variable and depends really on the nature of S&T activities undertaken in the respective institutions.

Type 5 (upper right): The establishments of this type are very similar in their strategic patterns and organization to the previous ones, except that in this case, the institutions concerned work in the domain of agricultural research and training on the one hand and computer science research and education on the other, with weak connections with social demand and developmental networks (a total of 4 institutions).

This typology acounts for 18 of the 29 institutions investigated. The remaining units approach the others only very loosely and are thus intermediate between many categories or else have no clearly discernable strategic features. Thus, we find a fair number situated very close to the origin of the first two dimensions.

A remark on the foreign collaborators of the selected institutions would not be out of place here. For, while it is found that collaborations within the Arab region are not a discriminating factor (pan-Arab cooperation being an all-pervading feature; for instance a

strong collaboration between countries as distant as Syria and Morocco), the European Economic Community, North America and Japan present very interesting collaborating patterns. Indeed, while the Japanese tend to collaborate with petrochemical and industrial research units in the Middle East and which depend heavily on the State (type 1 institutions), the EEC and North America show collaboration links with higher educational institutions which are structured according to the Western model (type 4 institutions).

III - DEVELOPMENT AND INNOVATION: THE COMPLEXITIY OF SOCIAL DYNAMICS OF S&T ACTORS IN THE ARAB WORLD

I-1. Arab states independence and S&T autonomy

Most of the Arab states have been politically dependent until recent years. Under colonization and under international mandates, public policy run by European dominant countries has been reluctant to the construction of indigenous techno-scientific systems. For the former ones, developing professionnal skills involved in these systems would have, indeed, borne political risks. Engineers, especially, have been considered as nation-state builders for the physical as well as technocratic infrastructures[28] . Shaping the material world and providing human resources for public resonsibility positions, they are leading actors in a society's project. Under such circumstances, European powers have only lately favored individuals' professional training in these sensitive fields and they did it mostly in their metropolitan institutions. This is especially the case of countries like Algeria.

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[28] cf A.GRELON, Les ingénieurs du Maghreb et du Moyen Orient: vue d'Europe, in LONGUENESSE et alii, Bâtisseurs et Bureaucrates, Ingénieurs et Sociétés au Maghreb et au Moyen Orient; Maison de l'Orient; Lyon 1990

Nonetheless, some institutions, the american private universities in Cairo or Beyrouth built a hundred years ago for instance, have contributed to some extent to keep alive the academic traditions of the Islamic world.

Unsurprisingly, after having got their independence, a major concern of the new independent countries has been to set up their own S&T capabilities. May be more than in other LDCs, this objective was emphasized in Arab politics as a strong necessity for building up an industrial society. The rise of techno-scientific communities is thus definitely associated with specific national and political projects. These communities got legitimacy and social recognition from the fact that they were supposed to improve the general standard of living in the population. The people expectations thus met the purpose of these new groups. Setting up techno-scientific communities is a crucial issue with a symbolic as well as strategic value, for two reasons. First, it is a proof of domestic capacity for endogenous development. Second, it is a practical tool for socio-economic modernization. The status given to technology and science in the development process thus fostered the emergence of new significant actors: all the people professionnally involved in this process. Meanwhile, these new actors were expected to contribute to the erection of a national community. Professionnal horizontal relationships oriented toward national development goals and bypassing traditional, vertical links were redesigning relevant associations in society. The emphasis on S&T was translated in national planning and budget by significant institutional investments in this sector. Educational centres were created quite early to provide the States with technical competences needed for their industrialization objectives. School of engineering thus appeared, especially in the countries having chosen heavy industries options such as Egypt in the 50s and Algeria a decade after[29] . Consequently, since the post-war period the number of engineers in Arab countries has been multiplied by

[29] cf E.LONGUENESSE, Ingénieurs au Maghreb et au Moyen Orient, politiques de développement et nouveaux acteurs sociaux, in LONGUENESSE et alii, Bâtisseurs et Bureaucrates, op cit.

20 and reaches a level of 380 000 today[30] . Being the agents of States development strategies they mostly depend on the public sector for employment.

Due to the importance granted to them, scientists as well as engineers have been considered as professionnal "elites" in the contemporary Arab social organisation. However, the current crisis of the development models and strategies to which they have been associated affects their position. They also feel very much concerned by the political debates about democracy, which is tied to development issues drawing on S&T.

III-2. Arab societies, development policies and the role of experts: a complex issue

As shown in first part of this presentation, S&T and society's development can only happen and contribute to each other if they continuously go through a mutual adaptation. Building up S&T capabilities is not sufficient to implement development strategies as long as the appropriate connection with societal issues is not ensured. The contents of science and of society must be redefined by actors through negociation all along the innovation process.

In Arab countries, the adaptation between scientific and technical experts to socio-economic issues have often been one sided. Either the former ones have bet on a social situation which was, in fact, irrelevant to their scientific and technical assumptions, or the latter ones have evolved without the experts being able to react to shifting conditions. An example may describe this phenomenon.

In Jordan[31], as in many Arab countries, a major concern of national authorities has been to

[30] cf A.ZAHLAN, Formation et emploi des ingénieurs arabes, in LONGUENESSE et alii, op cit.

[31] R.BOCCO, La sédentarisation des pasteurs nomades: les experts internationaux face à la question bédouine dans le Moyen Orient arabe (1950-1970), in Sociétés pastorales et développement, Cahiers des sciences humaines de l'ORSTOM, vol 26, Nos 1-2, Paris 1990;

improve the agricultural sector's efficiency. It often consisted in changing from a traditional extensive agriculture to a modern intensive one. According to current scientific and technical standards, the only way to do that was by conventional, westernlike, farming with fixed lands appropriation. Only then could modern technologies (irrigation, fertilizers and mechanization) be used efficiently. There was just one problem: the rural population itself, to which these projects were targeted. The bedouin tribes have indeed basically a nomadic way of life with extensive cattle raising resources. In their complex social and ecological system, equilibrium between settlements and nomadic areas is clearly established and managed. Distribution of space and its potential resources is thus different from the one that the experts had in mind. Local as well as international agricultural engineers followed the dogma taught to them and promoted by the intergovernmental organizations such as the UNESCO, FAO, UNDP, WFP... Where the bedouin conceived a fully integrated system with optimal resources management, they considered a dual, inefficient economy characterized by an agricultural space division. It is easy to see that their collective representation of space and resources was derived from scientific assumptions established under extraneous empirical evidence. Experts did not focus on local data collection and analysis but rather attempted to apply a scheme that their education and training had led them to consider as universal.

The former example does not reveal that western, mainstream, science to which the experts are affiliated is irrelevant. Jordan has indeed increased its agricultural production as a whole despite 91% of its territory is arid or semi-arid. But it now imports 60% of the meat required by the market, a situation which could have been avoided if nomadic tribes production would have been developped rather than left aside on scientific biased assumptions. At the same time, desertification expands because of the exclusive reliance on

and also, Ingénieurs-agronomes et politiques de développement dans les steppes du Sud Jordanien (1960-1985), in LONGUENESSE et alii, op cit.

agricultural solutions at the expense of pastoral ones. Environemental damages are direct consequences of experts misconceptions about the *milieu*. What this example means is that the contents of science as well as its application, erected through local and circumstancial experiments, have to be reconsidered when facing new socio-natural conditions. This can only be done by taking into account the significant actors in these situations: humans, of course, but also nature as it is a mix of both which determines the process.
In the previous instance, we may suppose that there was a broad array of potential improvements between intensive crop raising and extensive cattle raising. However, such improvements would have required a blending of local and exogenous technologies, a mix of traditional measures and modern equipments. These solutions have not been explored and negociated with the bedouin actors. Beyond the failure of such local projects, it is the modern identity of the Jordanian society as a whole which is at stake. Jordan, as a State, is indeed looking for economic development. But it also wants to keep its integrity and specificity to which the bedouin culture's contribution is highly valued. Therefore, the State is leading a very ambiguous and contradictory policy in putting at risks nomadic tribes existence and wishing their stability at the same time. This example shows that an inadequate scientific and technology policy thus leads to an unacceptable socio-political dilemna for the Nation-State actor: choose between economic development and cultural authenticity. Both are necessary for its legitimacy. Such conflicting issues are frequent in the Arab world and do explain part of the crisis that it is facing today.

III-3. Momentum in the Arab world: Social change, Islamism and S&T

Today, in Arab countries, the situation is quite uncomfortable for S&T actors. States modernization programs and development models are put into question. The relative failure of developmental approaches based on S&T assumptions biased by western standards strongly affects the credibility of such options. Consequently, unsatisfactory social changes generate actors grievances toward such kind of modernization. However, frustrations due to unmet expectations of life conditions improvement are not only expressed by a significant part of

the general population but also by the S&T communities themselves. They react in accordance with the rest of society, with often a higher critical stand point. For a long time associated with the States' deceiving modernist approaches, they are especially concerned by this failure.

In fact, Arab S&T communities are the first to be affected by the current situation. As mentionned above, State policies have fostered their development since the beggining. In the field of technology many actors have thus come to existence. But their social integration has not followed to the same extent. Disconnected from actual economic situations, many engineers have a hard time to find a position. Unemployment in the profession is high. Engineers' absorption by the job market depends on industrial activities. These remain limited and the education and training received by local engineers may not often be adequate to domestic industries.

The petrochemical, high tech, sector of oil exporting countries draws more on foreign specialists than on limited local engineering abilities. There is a paradoxical situation in which western experts are called for a temporary, highly specialized mission while the country's engineers are left out of job.

In other countries such as Morocco or Tunisia, some industries have reached a certain level of development: phosphates/fertilizers and clothes, especially. However, this sector is limited to a few branches and does not create an industrial web with an active engineering profession.

The case of Algeria is even more striking. Two decades ago, this country chose an import substitution development strategy based on the expansion of the heavy industries sector. National planning has thus favored steel industrial plants and firms have participated to the creation of engineers educational programs designed to their needs[32] . The restructuration of this sector at the international level has led to a dramatic shift of conditions for these groups of people employment. With lots of high tech involved now, the steel industry

[32] cf M.BENGUERNA, A.KADRI, La formation des ingénieurs en milieu industriel algérien: l'exemple de l'ingénieur CIFI, in LONGUENESSE et alii, op cit.

requires foreign experts supports. What was supposed to be the substrate for the edification of a national technical capability has then become dependent on outsiders cooperation. As in other Arab countries, without adequate training and limited to auxilliary roles to foreign experts, local engineers lack imaginative and innovative skills necessary for endogenous development[33] .

To describe it in simple words, governmental authorities in Arab countries have relied on a "scientific and technical push" rather than to wait for an hypothetic "market pull", for economic development. To avoid a waste of tenuous resources, they have bet on some sectors for which they created actors that they carried to an elite status. The industrial development for which these actors were provided did not occur. More numerous than ever before and without substantial employment, S&T actors are facing a professionnal devaluation. Victims of failing national modernization projects, they actively participate in social undertakings suggesting ideological alternatives. This is the reason why various islamist movements have a strong representation in S&T spheres[34]. Their professionnal organizations are, indeed, often managed by leaders pertaining to Islamist political parties, sometimes moderate sometimes radical. Therefore, it is often the intellectual "avant garde" which raises islamist flags for social reconstruction in these countries. Islam cannot thus be simplistically classified as obscurantism, irrationality or backwardness. It is rather a reaction against an S&T and social development on western standards which has proved to be inadequate for the Arab world. Beyond previous mimetisms, is there an authentic scientific and technologic development possible under islamic rule today? Historical evidence gives a positive answer to this question, as it has been shown in part one. Islamism is not anti-western *per se*; it is a claim for authenticity and for...democracy. What the actors want is, indeed, to keep control over development in their own society. If S&T development is only built along western standards exclusive of local, contextual situations, then it might push

[33] cf S.HANAFI, La formation des ingénieurs en Syrie et son adaptation aux besoins de la société, in LONGUENESSE et alii, op cit.

[34] cf F.BURGAT, L'Islamisme au Maghreb, La voix du Sud; Karthala; Paris 1988

Arab actors into reactionnary behaviours.

We, in Europe, must be aware of this: our direct partners, in S&T development there, may not exactly have the same societal objectives as ours here. But their religious beliefs may completely be compatible with resources development through S&T. This requires adaptation through negociation at every stage of the innovation process, between S&T actors and others, between Arabs and Europeans. During the transfers, S&T actors have thus to be ready to reconsider the deeper contents of science and technology if necessary, in order to match social expectations which are themselves evolving in the negociations. It is a two way process which, indeed, requires from the actors to drop two current assumptions:

-a positivist view that there is an *episteme* transcending human social factors, that science and technology elaborated anywhere has, then, intrinsically a universal value. Observation shows that science as well as technology are always contextualized and carried by actors and intermediaries.

- a schyzoïd conception that society is an organic body in which technical change necessarily introduces a painful dichotomy between tradition and modernity. History reveals that innovation and tradition are permanently re-invented and often mutually contribute to their redesigning.

Technology as well as science appear as a black box[35] . Any technological device holds together an heterogenous set of elements which have gone through an aggregation process. Once the process is closed, it is often considered as an objective resource in itself, available for use independent from the conditions in which it has been elaborated. This is to forget the many circumstancial constituents which are part of the whole construction. To understand technological change, we have "to break open and to examine the contents of the black box in which it has been consigned by economists"[36]. To implement technology transfer,

[35] B.LATOUR, La Science en action, Paris, La découverte, 1990

[36] N.ROSENBERG, Inside the black box. Technology and Economics; Cambridge University Press, 1982

"recipient" actors might often disaggregate the elements in the black box, in order to recombine them in locally proper configurations. This is close to what muslim public policy officials and scholars suggest when they talk about "depackaging"[37]. The technology package may be opened and reshaped in an appropriate manner if local competences are available.

In fact, the current situation in Arab countries still holds many opportunities. They have human resources available for scientific and technical tasks. Today, these actors are willing to express and defend their society' specificity through islamism while improving its material conditions. Therefore, they might be able to translate exogenous innovations into adaptative configurations, better than ever before. Their mediation between western laboratories and Arab populations can be very productive. This is a momentum; opportunities lie there; waiting too much would behold risks of radicalisation due to rising professional and social frustrations. Of course, in S&T transfers, actors have to get prepared to understand the technology proposed, in order to be able to depackage it. For instance, training and education should, thus, be provided with the package. This can be done through effective cooperation along the transfer process. Do we have the tools to do that at a european level? How can we implement such kind of transfers today? This is what we look upon in the following part.

I - 3. Collaboration vs competition: transfers at a crossroad rather than in a dead end

The European Community has a programme for S&T cooperation with developing countries: the Science and Technolgy for Development (STD) of DGXII. The general budget of this programme amounts 80 Millions ECU for the STD2 and represents 1.5 % of the community's current research framework (1987-91). Though significant, this budget is relatively

[37] UNCTAD, op cit.

small compared to big industrial R&D community's programmes such as ESPRIT (information technologies) or RACE (telecomunications). The STD3 (1991-95) should be raised up to 120 MECU. STD is mostly a programme with Cost Shared actions, the commission financing half of the research projects. These are works associating European teams with some laboratories in developing countries. The average number by projects is of 3 teams, 2 european with one from a developing country. The programme only deals with medical and agricultural research.

The number of teams from Arab countries involved in the STD2 is quite small. Most of them are maghrebin countries, Morocco being the first, then Tunisia and Algeria. These countries are very often together associated in the same projects with France being their main partner in Europe. Through this program, Spain develops scientific links with Morocco and Egypt too. Machrek countries (Middle East) do not appear significantly as beneficiaries of funds from the european program. On the northern bank of the Mediterranean sea, France, Spain, Italy and Greece are frequently associated in research projects of STD2. There is thus a web of scientific relations across Mediterranea, France being at the core of these networks. Nonetheless, this web could be extended and diversified. Its nodal interconnections' focus on France is a center for extension not a concentration to be saved. The ground is already prepared for such an extension. Inter-arab relationships are very dense already and European ones have expanded very much also with CEC programmes. Connecting two partners across Mediterranea, thus often means networks concatenations. There is a wide spectrum for deeper involvement, at a European institutional level, with Arab countries on themes related to Mediterranean development.

Considering its focus on agricultural and medical research, we cannot expect the impact of the STD programme on industrial development to be significant. It must not be forgotten that teams based in European countries are the only ones to participate in the high tech industrial programmes. These are strategic for the competition with Japan and the United States and thus exclude outsiders. Today, therefore, the world tripolarity actually overdetermines the North-South S&T cooperation and its impact on development.

Is there a way our institutional commitment in S&T cooperation could be enhanced and

improved? Apart from financial involvement, we may suggest an original way of fostering cooperative links between Europe and Arab countries. This is driven from our experience on the Medical & Health Research Programme (MHR4) of CEC DG XII. This programme is organized in Concerted Actions rather than Cost Shared Actions. Concerted Actions are research projects gathering a significant number of teams (from 10 to more than 100) working on a similar or close topic. The CEC does not financially contributes to teams' work as such. It only provides funds for exchanges between them. All forms of exchanges: workshops/meetings, staff, computing, samples, data, softwares, fax... everything that allows teams to effectively work together and get connected despite the distances. This networking strategy has proved to be quite successful[38] . It is indeed a powerful tool for knowledge and technology transfer. These networks, associating heterogenous actors from basic public research teams to private business firms or/and patients themselves, are constructive of health market developments[39] . Moreover, such transfers at an international scale are quite favorable to performance improvements in the Southern countries which were recently integrated in the EEC: Greece, Spain and Portugal[40] . Work sharing between teams and collective quality control enhance the general efficiency. As one Concerted Action Project Leader says, it is a "leveling by the top strategy", various teams getting aligned on the more advanced ones. Furthermore, every unit in the action takes advantage of the cooperation. For example, data collection for diabetes epidemiology, in many different countries under different conditions, provides a bigger and better sample which allows more sophisticated and more acute analysis. The cooperation process is synergetic; it

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[38] cf P.LAREDO, D.VINCK, J-B.MEYER, B.KAHANE, The research networks built through MHR4, CEC report, 1991, forthcoming

[39] cf J-B MEYER, The dissemination of Concerted Actions results, in P.LAREDO, D.VINCK, J-B.MEYER, B.KAHANE, op cit.

[40] cf D.VINCK, Les réseaux Nord-Sud intra-européens en matière de recherche médicale: modes de coopération et types de partenariat; Congrés PRELUDE, Le réseau, mode d'emploi, Namur, Novembre 1990.

is not a zero sum game, the bulk of the results is higher than the addition of separate contributions.

Is this kind of scheme duplicable in North-South, Euro-Arab S&T relationships ? The answer is not yet given. Concerted Actions may not be the panacea for european public R&D management. However, it shows that innovative financing procedures may provide the tools for significant advances in collaborative trends.

The last point we would like to emphasize deals with theoretical economics of innovation. Recent works show that the innovation process leads economic actors to increasingly develop alliances among themselves and others in order to secure markets[41] . Firms build horizontal and vertical links with other firms and research centers. The idea is that, in today's complex world economy where product life cycle is short, the market differenciation high and with heavy financial investments, no one can deal with such a level of uncertainty on his own. The innovation process requires a control of such a big diversity of elements that partnership is necessary to ensure that supply and demand have any chance to meet on an intractable evolutive market. For the firms, these associations allow a better use of complementary assets eventhough they may be rivals in other time sequences of the development process. It does not mean that competition completely disappears. But it suggests that the market is fragmented in areas of competition and collaboration. Such an approach takes some distances with the neo-clasical market model of pure and perfect competition. Consequently, it has an impact in international economics: comparative advantages or disadvantages on a rather uniform market become much more relative than in a Riccardian view. The terms in which the international competition (between the EEC, Japan, the United States and others) may be conceived are evolving. We have to take this into

[41] cf especially C.FREEMAN, Networks of innovators - A synthesis of research issues; International Workshop on Network of Innovators; Montreal, May1990 and L.K.MYTELKA, New modes of international competition: the case of strategic partnering in R&D, Science and Public Policy, vol 17 No 5; October 1990

account in our new approach of global interdependence.

Especially, the output of the innovation process is generally highly specific[42] . The relationship between innovators and users is very close. The innovation is itself a product of a very specific, individualized set of connections between actors: those who conceive it, those who develop it, those who use it. Actors purposes are embedded in technology as well as actors incorporate technology requirements. The irreversibility of their relationships increases during the innovation process: the more the actors have been involved in the process, the higher the cost to shift from one actor to another or to drop one[43] . This analysis is valid for various types of innovation: the introduction of a new vegetal variety in a specific environnement by genetic engineering technics or the installation of a heavy equipment in a specific industrial plant with an automated production process. These individualized relationships drive us further away from mass production and consumption patterns in which competition is a mandatory rule.

CONCLUSION

Changing patterns helps to change behaviours. The network approach is an effective, operational alternative. Economic agents submitted to anonymous, mechanical market logics are substituted by socio-technic actors acting through networks.

Developing resources with Arab actors by such kind of particular relationships is a successful strategy for development. It is a way to locally expand collaborative vs

[42] the terminology is from O.E.WILLIAMSON; specificity of a good is opposed to generality; a specific good is less or not submitted to competition than a general one; cf The Economics of Organisation; the transaction costs approach; American Journal of Sociology, 87/3 pp 548-577.

[43] on irreversibility in economics, cf R.BOYER ed., Les figures de l'irréversibilité en Economie; Paris EHESS; 1991

competitive areas at the global scale and to generate symbiotic developments between the two sides of Mediterranea. S&T exchanges across the sea are a very strong incentive and opportunity to escape from confrontation scenarii where conventional approaches have left us. Tomorrow, by developing these new trends, the world may not be a theatre for trade wars between huge economic powers and for ideological antagonisms between cultural areas.

The purpose of our study is to contribute to a new model of North-South cooperation between the European and the Arab worlds. However, a closed model would here be an abusive reduction of the fabulous heterogeneity suggested in our approach: different cases, different actors, different situations and therefore different solutions. Our plea is rather for the elaboration of a *meta*-model, a spirit of action. The famous proverb "Think globally, act locally" gives a flavour of such a spirit. Networking and negociations could be the keywords. There are many ways of developing such a flexibility. A better knowledge of S&T conditions can help to choose the good ones. Exploring the fields opened by emerging patterns in social sciences does provide guidelines for action. But in our era of tremendous planetary changes, normative behaviours have also become obsolete. Consequently, no dogma should be taught except one: accept the world's heterogeneity and deal with it pragmatically.