LOCAL INNOVATION SYSTEMS, LEARNING INSTITUTIONS AND SOCIAL CAPITAL IN LOW KNOWLEDGE-BASED ECONOMY: THE CASE OF MAGHREB COUNTRIES

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INTRODUCTION

After three decades of repeated, if vain, attempts to join the group of advanced countries, Maghreb Countries (MCs) have come to realise that the way forward lies in the mastery of scientific and technological knowledge and its efficient application to the production of goods and services. They have still a long way to go on this, however. In comparison with the Science and Technology (S&T) policy experience of the newly industrialising countries (NICs) like Korea and Brazil, and also in relation to the challenges of development confronting the region itself, the S&T effort made by MCs since independence has generally been far from satisfactory. This relative shortfall in technological performance can be largely attributed to the incongruence of policy to the imperatives of sustainable development. A consequence of this has been the failure of the education system in the Maghreb to deliver S&T that is capable of translating into innovation and technological progress. Like many other Developing countries, MCs face enhanced competition, vanishing trade barriers, more stringent intellectual property regimes and deeper concern for the environment. Trends in all these areas are expected to pose serious challenges for fragile components in the socio-economic systems of the Region. In the face of these new challenges, viable National Innovation systems and competence building are yet to reached in this era of transition to the development of competitive national economies. In the Maghreb, as indeed elsewhere, the process of transition would involve the active

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role of the State aimed at promoting scientific and technological innovation as a basis for the development of a market-driven competitive economy. Efficiency of the market in allocating resources is enhanced with the supply of more and better information about new 'combinations'. These latter presume vision of the entrepreneur as well as the flair for innovation. All these complementary though competing requirements raise question with regards to the National System of innovation, both theoretically and empirically. From a theoretical point of view, it is important to question this policy instrument with regards to its viability to Daces, knowing that it emerged under specific conditions of high levels of technology mastery and accumulation. From an empirical point of view, the implementation of innovation policy in Maghreb countries raise several questions related to the effects and how efficient has it been in promoting innovation and growth and what are the prospects for future policy. Of particular concern for transition strategies is how well such strategies are adapted to the rapidly changing global techno-economic circumstances and their opening up to the free trade zone with Europe by the year 2010. Recent trends in technological progress and, in particular, the generic character of new technologies have led to the progressive loss of traditional areas of comparative advantages of the sub-region, namely through relatively low labour costs and rich natural resource endowment. These are no longer essential for accumulation and growth in the context of the unfolding global techno-economic paradigm. It emerges from various discussions held within the MAGHTECH network[2] that the Maghreb's techno-economic problem derives largely from policy-inflicted structural imbalances. These have made it difficult for the economies in the Region to respond adequately to the rapidly changing character of global production and market relations. [3]

I. PERFORMANCES OF THE MAGHREB NATIONAL SYSTEMS OF INNOVATION

1.2. R&D Policy and Innovation performances

Patent: The number of patents registered by MCs at the local patent offices in the last two decades and a half of the industrialisation process remains relatively low compared to Asia countries and to Israel in the Mediterranean sea. In Algeria 7930 patents were registered in the twenty-year period (1966-1986) at an average rate of 397 per year. The share of nationals did not exceed an average of 3 per cent, while 97 per cent were held by foreign firms (INAPI 1979/1988). This is the case of all three MCs, even though the figures have to be taken with some care considering the discrepancy, which sometimes exists between various sources. Compared to a small country such as Switzerland which scores more than 20 000 patents on average per year in the same period, or even a developing country such as Turkey, the gap is relatively high. However, in comparison to other countries and in particular to the East Asian ones, there is a relative scarcity of innovative activities in the classical sense of the word. It is more and more admitted that considering the current situation of most LCD's,

[2] The MAGHTECH (Maghreb Technology) network we have initiated in 1994 is the first network of researchers and policy-makers in the field of S&T for the Maghreb. Initiated by the author in 1994, it has become the most important network on S&T policy in the sub-region. Strong of 350 researcher from the sub-region and Europe working in more than 12 disciplines, it has held 5 international conferences, and made several publications to contribute to renovating the thinking on the issues involved.

[3] Djeflat, A. " S&T Policy Planning and Dialogue in African Economies " International Workshop, UNECA/IDEP/ ATPS, International Institute for Planning and Development Dakar 27-31, January 1997, 102 p.

they need to focus more on incremental, often within their reach, than on radical innovation. The Asian experience does not give evidence of the absolute necessity of fundamental research at an early stage such as the one the Maghreb is in. even though the early stages of Asian development differs from the current situation of MCs. From a sectoral point of view, it appears that the situation differs from one country to the other, the most active and efficient sectors in Morocco are medicine and hygiene (16 per cent) and chemistry (43 per cent of all), while pharmacy in Algeria and textiles in Tunisia appear to take the lead. While patents are one of the indicators usually chosen to benchmark innovation, in MCs a large proportion appears to be of the incremental type, not easily patented. Innovation in Maghreb enterprises can also thrive on informal R&D, although the extent of informal R&D is not fully documented. Some empirical studies of the iron and steel sector have for instance shown the existence of a non-negligible innovation dynamism of this type (Djeflat forthcoming). Paradoxically, another type of research, more of the basic and fundamental type, is conducted at universities, in various areas of knowledge: physics, chemistry, biology, computer science, geology and biochemistry. The issues of fundamental versus applied research is a highly debatable one. Other kinds of research are mostly research in agriculture where a limited number of centers are looking for certain varieties of crops to adapt them to the local environment. Although the issue of appropriate indicators of innovation in LDCs is an ongoing debate (Perrin and Abdelmalki 1998), we will use the classical approach to assess the R&D and innovation dynamism looking successively at the output of R&D namely patents, Scientific publications and exports of high technology products.

Publications: In terms of publications, out of 1229 articles published by Maghrebians during 1981-86, only 5.1 per cent of the articles were concerned with engineering and technology a relatively poor performance compared to NICs' rates. Over the last 28 years, the rate of growth of publications of MCs is higher than the Arab average. However, publications in international journals on S&T remain relatively limited: 0.32 per cent for Maghreb as a whole compared to 0.96 per cent for Latin America and 2.86 per cent for Asia; Publications are dominant in chemistry and physics. (Zahlan 1998)

High technology products and services exports : Global shifts in the structure of demand for manufactured products are working against raw material based sectors and in favour of technology and skill-intensive (new materials, telecommunication equipment, electronics, computers and software etc.). MCs are still lagging behind in this kind of products. The share of technology-intensive products in the output structure was in 1994, 15% for Egypt, 22.5% for Jordan and 24.1% for Tunisia. This compares unfavourably with Korea (41.0%) and Malaysia (50.2%). It is not however too bad considering that Philippines scores 22.6%, Turkey 19.5% and Thailand 24.6%.[4] In terms of exports, technology intensive manufactured exports represented 9.8% of total exports for Egypt, 20.7% for Morocco and 22.8% for Tunisia. This compares unfavourably with Philippines (47.4%) Thailand (48.3%) Malaysia (66.7%), and Korea (65.7%)[5] and not too unfavourably when compared to Indonesia (22.1%) and China (31.5%). [6]

[4] L. Abdellatif : Calculated from UNIDO INDST-4 digit. 1998

[5] Calculated from PC/TAS database, 1998.

[6] Both terms : high tech products or technology intensive products are used for the same meaning.

With regards to world competition, MCs are in a less favourable situation than most NICs and technology content in the structure of production are difficult to channel to the export structure. MC countries appear to specialise in technology-intensive products of the primary type e.g. : chemicals products.

II. INVESTMENTS IN NSI COMPONENTS BY MCS

Now that there is a general consensus that the way forward for the Maghreb is through the promotion of innovation and efficient technological capacity building in order for these countries to adjust to the rapidly changing trends of the global techno-economic system. New drive towards establishing effective innovation capabilities is emerging at the level of all stakeholders and notably policy-makers at government level.

New institutions and bodies: Various bodies were initiated in MCs: they include new purpose-made institutions, R&D co-ordinating institutions, and ministries or Ministerial delegates. In Algeria, a Ministère délégué à la Recherche Scientifique et Technologique (MDRST) is appointed in 1998 together with Orientation and co-ordinating bodies (Conseil National de la Recherche Scientifique), Inter-sectoral Commissions and sectoral Committees, Research Co-ordination Directorate, National Agencies for Health Research, university research. Similarly, in Tunisia, a Secrétariat d'Etat auprès du Premier Ministre chargé de la Recherche Scientifique et Technologique is born in 1998, together with National Commissions, Directorates and intellectual property protection agencies [7]. On top of that various specialised technical centres were created in the fields of Mechanical and Electrical industries, building materials, leather and textiles. These technical centres constitute good indicators of the priority sectors, which the country is emphasising. From a financial point of view, several other support institutions were built namely the fund for the promotion of S&T research: F.O.N.A.P.R.A. (agriculture), le F.O.P.R.O.D.I (industry) and F.O.P.R.O.D.E.X (exports). One of their main tasks is to establish links with the users of research results. They could not however perform adequately unlike the French ANVAR, for example, which proved extremely successful in liking up R&D to market needs. Similar institutional architecture can be found in Egypt, Morocco and Jordan.

Regulatory framework : Most MENA countries have promulgated a specific law for the development of science and technology. In Tunisia, new laws were promulgated in the nineties: three of these appear to be directly linked to R&D: the decree n°94-536 of 10 March 1994, the new law of orientation of scientific research and technological development n°96-6 of 31 January 1996 and the Decree n° 99-11 of 4 January 1999. While all this legislation does not explicitly put forward the setting up of an NSI, programmes and actions put forward go implicitly in that direction. According to the 1994 decree [8], universities are allowed to contract directly with local or foreign institutions for the purpose of

[7] To date about 17 private enterprises have benefited from these grants.

[8] Decree, n°94-546 of 26 February 1994

undertaking studies, research, consultancy work as well as seminars, training sessions or colloquia, the costs of the services being fixed jointly by the two parties[9]. Part of the revenues is given to the academic personnel involved (up to 30%). In Algeria, the law promulgated in August 1998 [10] constitutes a real turning point, considering the detailed planning of SRTD (Scientific Research and Technological Development) it sets. It is geared specifically towards enhancing firm's capability to innovate, including both big public enterprises and private SMEs. The presidential decree status given to the text gives it greater enforcement power. Thus S&T research is set a national priority activity (art 2) and their aim is the economic, social, cultural and scientific and technological development of the country (art. 3). The novelty in this law is the role given to the private sector as an important actor of the development of S&T, even though, in terms of budget, the State keeps its central position. A new Investment code was promulgated in 1993 to give potential investors the best possible conditions for their investment.

Investment in education: It is widely recognised that MCs have made a significant effort in the last two decades in educating and training their people: a large slice of Government budget has been allocated to education and training period reaching as high as 36 per cent of total government expenditure. As an illustration, until the beginning of the 1990s, Morocco devoted on average 7.3% of its GNP to education, a rate higher in many of those countries at the same level of development, and yet achieved relatively poor performances. Regarding basic education, a large proportion of the work force in MCs is composed of young people and adults who have completed primary education only (Bouayiour et al. 1998). However the situation differs from one country to the other. The average duration of full-time schooling is 5.1 years for all levels of education in Morocco, while it is 8.3 years for all other Arab countries and 7.4 per cent on average for countries elsewhere in the world with similar GNP per capita to that of Morocco. With regards to higher education, the total number of students has steadily increased over the last two decades with a significant increase in women participation. Local universities offer training for degrees up to masters level in all three countries (Alcouffe 1994). 2.5 since have multiplied the number of students, with an acceleration for certain countries such as Tunisia. The output of higher education ranges between 10 000 and 30 000 each year. The rate of graduates on average reaches 120 to 220 per thousand.

The education system: Both, the shortage of qualified workers and scientific manpower, can be attributed to a large extent to the failures of the education system, both with regards to basic education and basic training and graduate formation. The weak educational basis which did not provide firm grounds for building adequate competencies, results from obsolete pedagogical methods which do not encourage awareness and creativity, old curricula, the absence of periodicals and the limited involvement of private initiative in education and training. The percentage of Moroccan school age children in full time education is known to be the lowest in the Region. The rate of graduates on average reaches 120 to 220 per thousand compared to France, which scored 246 in 1994 and yet achieved relatively poor performances notably an enrolment rate of 40% for the 4 to 23 age group:

[9] 30% of the proceeds are given to the researchers involved .

[10] Law n° 98-11 of 22 August 1998 : called 'law of orientation and Programmes dealing with the five year plan for the development of scientific research and technological development *(Loi d'Orientation et de Programme à Projection Quinquennale sur la Recherche Scientifique et le Dévéloppment technologique) 1998-2002*

55% in the primary school age group and 36% in the secondary school age group. The rate of illiteracy remains one of the highest in the world, at almost 50% of the adult population while it reaches 40% in Algeria and 31% in Tunisia. This results partly from the weakness of the training system: Algeria which trains 39 engineers par 100 0000 inhabitants, Morocco 11, and Tunisia 77[11], whereas Singapore, for example, trains 360 and Mexico and 358.[12] Moreover, most of these scientists and engineers are either in universities or in ministries and public bodies and not in industry or specialised research centres. Other weaknesses include the relatively low moral and material status of researchers and their marginalisation, low degree of stability and inadequate motivation, bad research conditions and the indigent state of universities forcing them to emigrate.

Weaknesses of scientific and technical training: Graduates in social sciences and humanities represent between 50 per cent and 60 per cent of the total number of graduates of higher education. Graduates in natural sciences and technology are in a minority situation except in Algeria their proportion is around 50 per cent are in Science and engineering. In the last five years these proportions have not improved much showing that no one country has been able to increase its proportion of scientists, engineers and technicians. This indicates that crisis in policy and means has seriously occurred leading to an important deficit in terms of science and engineering personnel required by the opening up of the economies and the innovation-based competition they are likely to face fairly soon. In terms of effectiveness in the field of S&T, investment in higher education has not produced research and development capability in MCs or where it has, R&D initiatives have for the most part remained remote from industrial practice. Vocational training has long been neglected by most MCs due to cultural (low status job) or historical reasons (inherited colonial orientation towards civil servants jobs for Maghreb countries). Yet, in many advanced countries and in NICs, it was given a high priority being considered as the bases for building effective and efficient capabilities for on the job training, for improving of skills, and for accumulation of tacit knowledge.

Funding of R&D activities: R&D initiatives in MCs have always suffered from the lack of adequate financing, resulting from both a limited awareness of the importance of innovation and the weakness of domestic savings and chronic budget deficits. In spite of non-negligible efforts made, R&D expenses did not exceed 0.30% for Tunisia (1997), 0.2% for Morocco (1996), 0.3% for Algeria (1997). OECD countries scored 3.05% for Japan (1996), 2.66% for Germany (1996) and 2.25% for France (1997)[13]. This is in spite of the fact that economic demand for new and high technology remains relatively important as shown by the deficit in the technological balance of payments (TBP) which deteriorated from -87, 7 million DT in 1991 to -128million DT in 1994[14]. It is recognised that some non-negligible efforts were made in the late seventies and early eighties, and funds allocated to research have effectively increased particularly in countries like Algeria, Tunisia and Morocco. Taken individually, MCs compare

[11] Bouayiour, op. cit

[12] Worls Bank report 1993

[13] SERST (1996)

[14] SERST report 1996.

unfavorably with Newly industrialising countries: expenditure on R&D in Morocco amounts to 2 dollars per inhabitant per year (0.2 per cent of GDP in 1990). This proportion falls short of the ones achieved by India (0.9 per cent in 1987), Korea (2 per cent in 1987), Brazil (0.6 per cent in 1986) and Mexico (0.6 per cent in 1986). At enterprise level, the effort made in the area of R&D is weaker: 10 per cent only of total R&D funds are from enterprise budget while 90 per cent are funded by State. In Tunisia, internally funded R&D by enterprises does not exceed 6 per cent. However, the trend shows that private funding has been growing at a higher rate (Lahzami 1998). Figures for Algeria show that particular effort is being made to reinforce R&D in priority areas and that the rate of growth of allocated funds can be quite substantial[15]. 0.7% of GDP were devoted to R&D in 2001 out of the 1% targeted for 2002 for SRTD in order to foster firm-level innovation and university-enterprise links. A national SRTD budget is voted each year by the parliament. However, it is not the sole source of funds: contributions are expected from public and private institutions, research contracts and external funding from international funding agencies and co-operation.[16]. In Tunisia, the financing of R&D practically doubled in the 1992-1998 period going from 33 253 DT (Tunisian Dinars) to 65 619 DT. In 1998, public funds share reached 88%, funds from foreign institutions representing only 3.9%.[17] An important jump is expected from the 8th development plan to the 9th plan from 42 million DT to 151 million DT, an increase of 300%[18]: 44% of these funds will be allocated to the establishment belonging to the Secretariat d'Etat à la Recherche Scientifique et à la Technologie. All three MCs are aiming at reaching the 1% of GDP.

M*obilising existing human potential*: The personnel involved in R&D in the MCs is on average 10 to 20 times less than in Europe. For all countries of the Maghreb, the number of scientists and engineers involved in R&D is less than 400 per million inhabitants. In the same period Europe had 1735 (Bouayiour et al. 1998). The total number of FTE (full time equivalent) researchers in 1996, amounted to 19100 in the whole Arab World, 66.3% of which, were in government R&D units, 31.6% in universities and only 2.1% in the private sector i.e. a relatively low ratio of 0.30. The number of FTE researchers in OECD countries amounted to an average of 4.6 per 100 000 for a total R&D personnel average of 9.4% with disparities: the highest scores being in USA (7) and Japan; The use of foreign technical assistance is not as systematically as in the past showing a new attitude geared towards the mobilising and reinforcing the local S&T potential. This is done through the 'Centres of excellence' policy planned in several MENA countries notably in the Maghreb: 10 in Morocco, 6 in Algeria and 5 in Tunisia specialising in various fields: advanced technology, energy, environment and water, social sciences, agriculture and life sciences. The number of researchers mobilised appears increasing in all MCs: Algeria indicates the figures of 3870 part-time and 1915 full-time including those in centres of excellence.[19] The human resources needed to implement the national SRTD programme (1998-2002) are quite considerable:

[15] taken from IPTS report p. 13.

[16] Hardy, P. & Bontoux , L. op. cit. p. 11

[17] SERST, 1996.

[18] La Presse 22 October 1998, p.7 and Ch. Lahzami op. cit. p. 12

[19] Hardy, P. & Bontoux , L. op. cit. p. 11

the total number of researchers is expected to grow at an average rate of 150% in the period to reach a total of 15 915 by the year 2002[20]. Tunisia appears to have 6000 academics doing part-time research[21]. In Morocco, there are about 10862 part-time researchers employed in universities, training institutes and high schools, while 2538 doctors and engineers are involved in research activities in public or private institutions. A study conducted by the CNCPRST (Centre National de Co-ordination et de Planification de la Recherche Scientifique et Technique) in 1995, reveals the existence of about 910 research units and teams within 118 institutions: 90% of these belong to the public sector (80% in universities) while 9% are semi-public and only 1% are in the private sector. The number of R&D projects rose from 2229 in 1994 to1700 projects in 1997[22]. In the nineties, 9534 people were employed in 126 research institutions 19 of which were research centres: 60% came from the Ministry of Higher Education. Resources are allocated differently from one sector to the other: the largest share is taken by the agriculture sector in the majority of MCs. In 1996, the share of FTE researchers reached 44.2% in agriculture while industry had only 8.5%, basic sciences 8% and Engineering 6.3%.

III. PROBLEMS MET BY THE NSIS IN MAGHREB COUNTRIES

The disintegration of NSIs in the Maghreb originates from both the problems and difficulties met within each pole and in the relationships between the various poles. It is worth examining these problems. Neither the market in the Maghreb economies nor the State were capable of building adequate National Innovation Systems. Our own work (Djeflat, 1985) on the industrial strategies and implementation of a systemic approach to the so-called 'industrialisation model' in countries like Algeria largely inspired from the François Perroux/De Bernis conceptual framework has pin pointed to a host of obstacles imbedded both in the concept used and in the bad implementation of the initial model. It then appeared that the national state as "a 'container' of social processes and the national framework were not best suited to measure and analyse these unforeseen changes. While policy options and national choices mostly of the "volontarist" type accounted a great deal for the limited insight, clear indications showed that the role played by international institutions mostly for Europe and United States failed to trigger off and contribute to build what both imperfect markets and imperfect states failed to engineer and promote in the field of innovation and system construction. Worst, it appears that the role played in deepening distortions in the three components of the NSI is non negligible through notably restrictive practices, inadequate contractual arrangements, brain drain encouragement and sub-optimal investments. Meanwhile, various initiatives are taken to benchmark the innovation systems and competence building strategies in Europe and the other countries of the triad. As put by Lundvall, they are likely to further exacerbate the growing gap in access to knowledge between the rich core (US, Europe and Japan) and the rest of the world.

[20] Decree n°62-98 of 24 August 1998 (*) no precision given whether they are full-time or part-time researchers.

[21] Lahzami, Ch. Op. cit. p. 12

[22] Government programme, July 1997, p. 98

In the education sphere: In universities, personnel involved in academic research does not devote more than 10% of its time to effective research as a result of increased demographic pressure and teaching loads. Beside the weak numbers, published figures show that the bulk are involved in science research while those involved in real technological research represent between 10% to 20% in the countries for which statistical figures are available. Maghrebian researchers seem to perform better when the discipline are more abstract (physics) than when it is applied sciences (biology, medicine). This is due to a large extent to the fact that 75% of researchers are in universities and only 15.7% of S&T personnel are in Engineering and Technology. Paradoxically, the rate of unemployed engineers and scientific manpower in the region is estimated at 30%[23]. The relatively low status of researchers in MCs in particular has often been put forward as one of the most important problems facing S&T endogenising. This situation does not contribute to their stabilisation nor to their motivation.

In the research sphere: The R&D institutional framework (laboratories, sub-contractors etc.) is below requirements. These institutions, whenever they exist, are not operated to optimum capacity for lack of adequate staff, equipment, operational funds and scientific and technological support services. The equipment working life is shortened because of inadequate repair and maintenance facilities and the technical staff required to ensure that their scientific equipment will work well is limited. The quantitative and qualitative shortfall of technical support personnel for scientific and technological activities in R&D: in mid-eighties only 2 countries (Algeria and Morocco) had 2 technicians for every researcher engaged in R&D. (compared to 1 to 1 in OECD) and the slow rate of growth of FTE researchers (7.9%) per year compared to 11.6% for universities[24]. Moreover, whenever budgets are allocated to R&D activities, a great proportion of local funds are allocated to wages and salaries of the research institution's personnel. In Morocco, 95 per cent of the budget goes towards wages. However these competencies are often in a relatively short supply as seen earlier and also as a result of high pressures on production, which takes the priority over research and innovation as we have shown elsewhere. Little seems to have been done with regards to support services: documentation centres to institutions to valorise research results etc.

II. The revisited NSI approach

This section examine both in theoretical terms and in practice what approaches are likely to root the innovation function into the development strategies and implementation policies and build adequate competences. Strategies to pursue a system based approach to construct domestic innovation capabilities seem to attract a great deal of attention notably that NICs appear to have to various degrees and using various 'localised' approaches opted successfully for this approach.

From the empirical work, we have done on innovation, technology transfer and technical change in the Maghreb Countries, it appears that the NSI in its purest form, with the three poles approach cannot be a useful tool to analyse the weakness of innovation in LDCs and particularly in Maghreb countries. It needs indeed to take several factors into account and a broader methodological approach.

[23] Zahlan, *ibid.*

[24] Quasim, op. cit.

The national innovation system (NIS) has benefited from a vast and varied literature in recent years: Freeman 1982; Von Hippel 1976; Gilles 1978, Mowery and Rosenberg, Nelson 1982, 1984; Niosi and Faucher 1991). Various aspects were examined: the role of R&D departments in firms, the process of technological innovation, the important historical works of science, the concept of the 'technical system', the role of science, the role of the State in promoting technological innovation, the importance of technical alliances and co-operation agreements among countries etc. The integrated approach to the NIS was however put forward by Lundvall (1985) and revised in the nineties for LDCs. Figure 1 indicates the different interdependent components which make up the NIS:

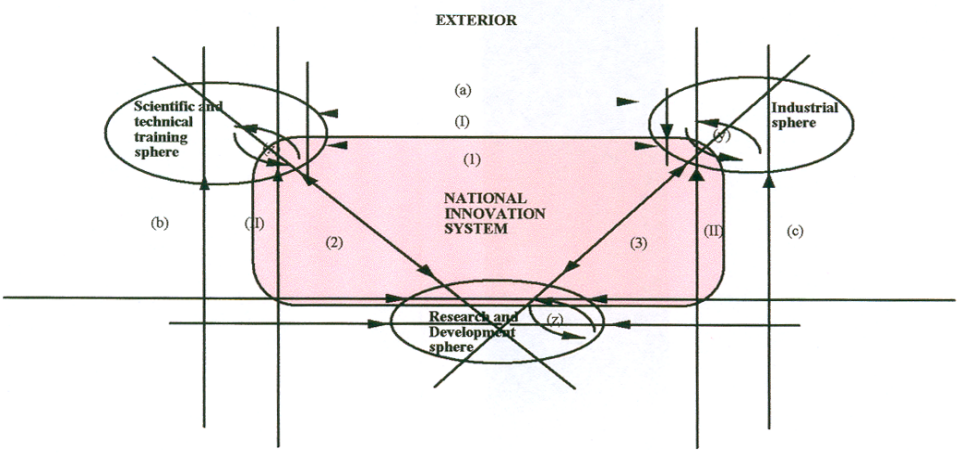

Figure 1 National Innovation System

The three spheres identified are: the productive sphere, the training and education sphere and the research sphere. Cooperation is essential between these spheres if the system is to work. In these relationships, the international aspect cannot be neglected particularly when the role of the most industrialised countries play in influencing, R&D trends is significant even if the national aspect is central insofar as technological development is concerned. Social and political institutions and economic policies as factors behind the homogeneity of Looking both at failures and success stories sub-optimal level of technological capability building in the Maghreb consequent upon the passive role played by the State in building adequate National Innovation Systems and notably its two major components: education and R&D systems.

2.1.1. NSI as an open system and its consequences on MCs

The importance of the international sphere as a highly relevant component of what might be an NSI adapted for LDCs, a 'fourth pole'. Our analysis of the Algerian industrial model a decade and a half after its implementation back in the eighties has shown that the so-called 'industrialising-industries' model proposed by De Bernis and effectively implemented has led to a highly disintegrated economy, with 'solid brick walls' being erected between the various sectors (Djeflat 1985). The explicit objectives of building an integrated economy with progressive intersectoral linkages could not take place. For example, domestically steel produced could not be used by the mechanical industry with the exception of its usage for the production of pipes for the oil and gas sector and often at very high and non-competitive costs. This is also the case of zinc and sulphuric acid produced in the plant of Ghazaouet

in the West of the country which could not be used locally but had to be exported to European markets at very low and unprofitable prices. At the same time, steel, zinc and sulphuric acid had to be imported for the needs of the local industry in a different shape! Many examples and case studies exist in this respect: they all convey the same lesson which is the difficult the negative effects of strong linkages both forward and backward with foreign firms namely suppliers of technological plants, equipment and services.

Figure 2 shows that it is an open system whereby several sub-systems are in continuous interaction: the education and training sub system, the research subsystem and the industrial sub-system, each one of these being itself open on other spheres both nationally and internationally (Bes 1995).

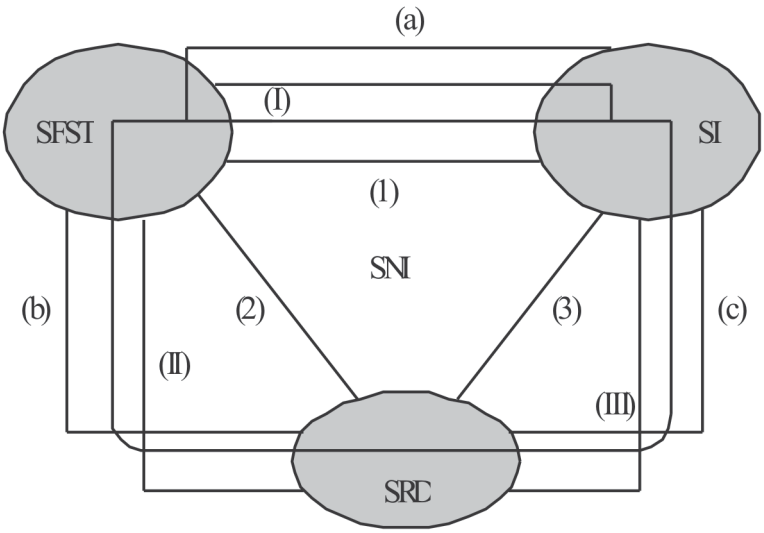

Figure 2 **The National System of Innovation as an Open System**
SOURCE: BES (1995).

From an empirical point of view, the interaction between the various poles and the external world take several features and can be illustrated by several examples. We see five major sources of disturbances and disintegration of the domestic NSIs in the Maghreb.

Concentration of research at TNCs head office and patents ownership: In most MCs, industrial undertakings are either fully owned or have a significant participation of TNCs. These latter carry out their research in their parent companies rather than locally. This often constitutes an inhibition to the development of local research. Whenever research is conducted locally, foreign personnel is preferred to the local one. A substantial share of the patents registered domestically is held by non-resident companies. The low share of patents from residents varies between 2 per cent to 30 per cent showing the crisis, which the R&D sphere knows, in spite of its gradual increase in both Algeria and Morocco. This is even more so, when we know that some of the foreign institutions have the status of resident in the country where they operate. While the issue of patent protection has been the centre of heated debate in the past, it does not raise as many controversies nowadays, as protection is seen as an incentive for local innovators and a way to attract big multinational firms. This very fact is indeed a point of concern. The steady decrease of nationally held patents in the Tunisian case, considered the most open and the most liberal economy of the sub-region, goes on for more than a decade; it

indicates that the Tunisian manufacturing sector is relying more and more on external innovation and less on its own capacity.

Brain drain: Maghreb countries have been relying on the specialised education and training facilities of European and to lesser extent American institutions to train students. Maghrebian students are present in 45 countries with a big concentration in France: 67 per cent of the total. This strong dependence on France raises several specific problems. French higher education neatly separates the university, which is oriented towards the teaching of liberal professions, and research and the Grandes Ecoles oriented towards training professionals in production and management of enterprises. Many of these graduates, tend to stay in France or to 'try their luck' in Canada, thus stocking up the 'brain drain'. They would tend to fit in adequately into the innovation systems of the host countries, amputating thus their own national systems of this precious human element.

Outward looking research: various research institutions and namely universities conduct a significant proportion of research locally. A glance at the results shows that most of the valuable research results are published in collaboration with foreign counterparts, mainly from France. A great deal of the Maghrebian authors who manage to publish either publish as co-authors with researchers from the North as shown in recent research (Zahlan 1998). This pattern finds itself repeated in the field of industrial research. An empirical study based on a survey of electronic firms in Algeria showed that in the majority of cases, the research carried out locally dealt mostly with themes inspired by the large multinational electronics companies operating locally and internationally rather than with the problems of the infant national electronics firms (Damien, 1994).

Dominance of external funding: The weakness of domestic funding, results in a relatively high involvement of external funding to support research (60 per cent of total budget). The problems related to external funding are numerous ranging from minor technical ones to more fundamental ones. The structural dependency of the national research systems, which are not given the chance to take off by themselves, may lead to a 'permanent infant research sector'. There are fears that this dependency on external funding increases over time now that there is a major squeeze on public funds as a result of the implementation of SAPs in nearly all countries as we have shown elsewhere. (Djeflat, A & Boidin, B. 2002).

Unbalanced power structure: The treatment of the power ingredient is of great significance in the interaction between the various actors involved. Previous studies have revealed that technology transfer was greatly hampered by the unbalanced bargaining power, which exists between technology suppliers who hold dominant position in the negotiation process. Consequently, a variety of restrictive practices and restrictive clauses in the technology acquisition contracts result. We have identified no less than forty-eight of these closes in contracts between Algerian public companies and foreign firms and also between Egyptian firms and transnational corporations in the oil, gas and petrochemical sectors (see Djeflat 1987; 1988). Often these restrictive practices hold imbedded the seeds of disintegration of the potential NSI, as natural or organised forward and backward linkages cannot take place. We have also in previous studies, highlighted the importance of other dimensions in the interaction process: notably commitment, distance, adaptation, conflict and cooperation in the process of technology transfer between high technology suppliers and low technology buyers (Djeflat 1992; 1998; Ford and Djeflat 1983).

2.1.2. NSI as a complex set of relationship between three poles

The NSI in its classical version is far from being a set of simple straightforward relationships. It appears that a complex set of relationship between three poles exists: the education, the research and the industrial one. The linearity of the system is questioned not only by theoretical contributions such as the Kline and Rosenberg (1986) model but also by the multiple institutions and layers of decision-making involved in minor projects of introducing new products, services or new working methods namely in the public sector. The limited performances achieved in spite of the existence of these three poles in MCs are an indication of this complexity and the existing of other parameters and other actors.

This can be seen through a first attempt made to characterise the national innovation system in Morocco (see figure 3). The variety of links and relationships, which are built and are necessary for innovative activities to take place, involves necessarily several elements. As pointed out by Lundvall (1985), elements of trust power, and loyalty characterise these relationships. These elements of cooperation and coordination are the only possible way to transfer the qualitative aspects much needed by innovation, as indeed the amount of tacit knowledge imbedded in each innovative activity cannot be catered for by the conventional contractual relationships. Scientific and technological research brings various agencies into play (political decision-making bodies, universities, research institutes and centres etc.). In the Maghreb, each one appears to follow its own logic and its own path, which are not necessarily compatible with those of other agencies. Other factors include the relatively bad research conditions, the reluctance to recognise the professional credibility of researchers forcing them to emigrate, the criteria used for career promotion which favour academic research and international recognition, the indigent state of universities, their relatively low material status compared to other professions. Finally, unlike Japan and Korea, the private sector is totally absent from R&D activities at least in the formal sector. Not much work has been done yet, exploring the degree of interaction between the activities of the public research centres and that of R&D of private firms and on the mileage to Maghreb economies arising from these.

Missing or difficult links between the various components. In most MCs, education policy is not matched with economic policy; nor economic policy with resource endowment. One of the main problems of university research is its isolation from industry as it has a very limited and non-institutionalised relationship with the local industry. Consequently, the influence of the education function on the production function of the economy, and hence on its absorption capacity, has been marginal; and this has left the economy fragile and potentially vulnerable to demographic pressures and other external shocks. Like education function, the technology function in MCs, has been supply-dominated. Consequently, while policy favoured 'supply push' technology and the education function, targeted at the modern sector of the economy, remained subservient to the prevailing technology function, the scope for indigenous innovation has been limited to learning by tinkering in the so-called 'informal sector'. But to the extent that the informal sector is disorganised and irregular, it cannot be expected to provide a robust basis for exploiting to the full, the indigenous innovative potential. The fact that MCs spend a lot for a relatively modest result reflects the economic inefficiency of the manner in which the education system is organised and managed. Higher education aimed at the accumulation of 'knowledge capital' can remain of marginal significance until the economy develops a sufficiently diversified structure. The transition is from supply push technology transfer and diffusion to need-oriented strategy of technology development.

The Industry Sphere: The productive system in the Maghreb is generally characterised by a diffuse structure. For instance, the industrial system in Algeria consists of less than 200 public firms covering the essentials of manufacturing activities without which the industry/research liaisons appear more developed, save for energy and petrochemical sectors. In this case, it is the differentiation and subsequent isolation of production activities with respect to suppliers and clients in a very bureaucratic system which has blocked possibilities for R&D spin-offs for a variety of reasons: 1) The 'passive technology consumption' which can be assessed in several ways: the optimal use of installed equipment and their maintenance and repair. 2) Optimal use of technology which is the first step towards the development of local know-how and technological expertise has not always reached the required level. 3) The rate of utilisation of industrial capacities in industry has been remaining at below acceptable levels: between 30 per cent and 50 per cent on average. The causes mentioned however are not all of the pure technological type relating to the surrounding environment 4) The limited capacity in local repair and maintenance of the equipment being used at enterprise level even though governments have encouraged the establishment of centres to repair scientific instruments and produce spare parts. We have seen earlier how mismanagement of technology transfer as a whole contributed to this.

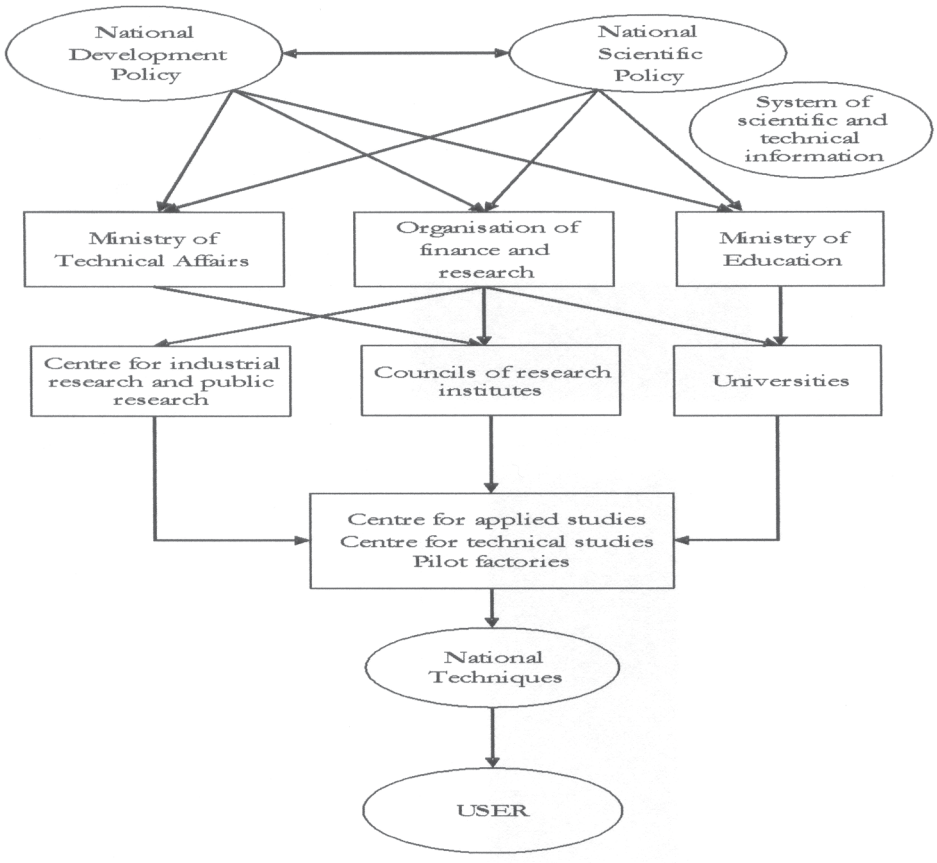

Figure 3 **The NIS as a Complex System**

SOURCE: (ZEKRI 1990).

Figure 4 shows how a need-driven system could be worked out.

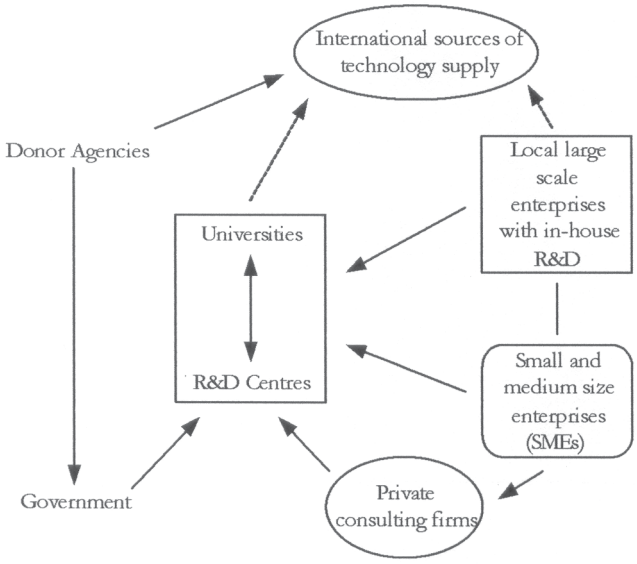

Figure 4 **Open and complex NSI**

III. ASSOCIATION WITH PARTNERS FROM THE NORTH

The system-building approach, with all its weaknesses requires some attention when considering the association with partners from the North. The innovation dynamics requires that two systems of innovation are connected simultaneously for the innovation process to fully take place. (fig.3)

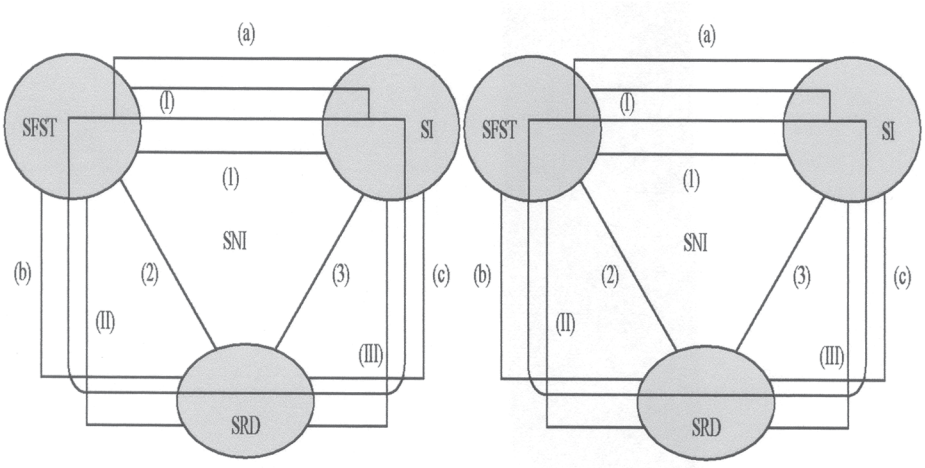

Figure 5: Two interconnected NSIs

The practices of partnership with the North by MCs over the last four decades shows that this condition of inter-connectedness is far from being fulfilled.

In MCs, association with partners from the north is within the framework of new institutional arrangements: European and united state free trade agreements being either signed or in the process of being concluded with both of them. Benefits are expected from either side. The Maghreb constitutes a huge and fast- growing market to develop for European industry while Europe constitutes a massive technological know-how and accumulated experience at the doorsteps of MC countries to reap. MCs on the other hand expect to derive substantial benefits in terms of increasing returns and technological spill over effects from these associations across a wide spectrum of economic activities to take their fair share of the « technology for all » programme [25]. MCs geographic proximity to the EU gives it large possibilities to expand its share of the world market through exposure to increased foreign competition and subsequent improvements in technical and economic efficiency. Comparative advantages can be easily gained in the areas of textiles and garments, leather goods, pharmaceuticals, and chemicals if innovation becomes part of their routine practices.

The attempts to link up Maghreb to European technological dynamics started in the early eighties. Three STD (science & technology development) programs (1983-1994): STD1 (1983-87), STD2 (1987-91), STD3 (1991-1994) and the inco-doc (international co-operation with developing countries: 1994-1998) have been so far initiated. However, they have left very little technological capacity. Out of the 6000 research teams, which were supported by the EU abroad, the whole Mediterranean region accounted for 289 research teams only (11% of the total) while Asia and Latino- America had 44% of the total. The most challenging aspect of this relationship remains without doubt the free trade zone agreement signed so far by Tunisia, Morocco, and Algeria and which is aimed at the elimination of trade barriers between the two zones by the year 2010. Consequently, European help is badly needed by MCs namely in technology transfer and the acquisition of know-how and in helping to put up efficient R&D personnel capable of innovative activities. Bringing domestic industry to European and international standards to face innovation-based competition constitutes therefore one of the main concerns of MC authorities.

The *mise a niveau program* (corporate upgrading programme) negotiated first with Tunisia and with Morocco and Algeria subsequently has a full-fledged national programme to bring local industry to European level by 2010 and to compete efficiently in the world market. In Tunisia, where there is the longest experience, the number of companies included into this programme has been steadily growing: 63 in 1996, 132 in 1997 and 165 in 1998 showing thus the rising interest of industry in the programme. 811 firms took part to the first phase of this program (1997-2000). Its objectives are to

[25] Djeflat, A. « The globalised Information Society and its impact on the Europe-Maghreb relationship » in Swasti Mitter & Maria-Inês Bastos « Europe and Developing countries in the globalised information society » UNU Press, Routledge London-New York, 1999, pp. 95-106

restructure the organisation of participating companies. Some 2,000 industrial firms are to be modernised for a combined bill of 2.5 DT[26] billion according to current estimates.[27] This should normally compensate the declining State revenues resulting from the free trade zone [28]. MCs are also in need of raising their IPR protection capacity, the upgrading of management and marketing skills, communication infrastructures, legal and jurisdictional system, social protection systems, the fight against poverty and exclusion etc. The MoCo (Monitoring Committee for Science and Technology) composed of representatives from EU and South Mediterranean Countries put the emphasis in 1996, in Cyprus on strengthening R&D of SMEs in South Mediterranean [29]. However, there is still a lack of a clear vision: no clear programs for upgrading R&D and innovative capabilities for instance exists. Internally, foreign funds gained from international co-operation are found to be badly co-ordinated which decreases a great deal from their impact on the scientific community. The MEDA II appears to have made some progress by introducing ingredients of 'mise à niveau' in area of S&T capacity building without properly tackling the delicate issue of the mobility people between EU and MCs. The fear of illegal immigration and international terrorism has relegated these issues to lower priority.

Conclusion: We have made an attempt to review the implementation of the NSI tool in Maghreb countries showing that the initial home-based, within national boundaries system did not very much work. An open and more complex system appears to better reflect the reality.

There are two major issues to be tackled simultaneously. The first one relates to the need of a real up grading of the existing components of traditional NSI: this applies to the education and training institutions, the limited but existing research institutions and of course industry, namely the SMEs. Industry, and particularly the public sector, suffers a general obsolescence of existing technological capacity. While considerable learning has taken place in the last few decades since intensive industrialisation started back in the seventies, subsequent financial and economic crises have reduced the chances of renewal of both equipment and know-how. All this is happening in the context of the crises of policy reforms, which result partly from a deeply rent-seeking system not very keen on seeing its various advantages being annihilated or not even, reduced.

Closer links and strong partnership will need therefore to be established between industry, universities and research laboratories. Personnel is also mobilised within industry both from the private and the public sector. Finally, the novelty is the participation of national competencies living abroad and whose number and capabilities are relatively high.

A considerable effort and new dynamics needs to be insuflated in the relationship with foreign, entities. The new orientation towards the opening up of Maghreb economies in front of big international firms raises the issues of their effective participation in endogenous S&T capacity building. In this respect, the role of foreign direct investment, which highly sought by all the countries, still remains relatively ambiguous when it comes to building S&T and innovation policy.

[26] DT: Tunisian Dinar , the local currency worth roughly 2 USD to one DT

[27] North Africa weekly review, op. cit.

[28] The North Africa Journal, 14 February 1999

[29] Hardy, P. & Bontoux , L. op. cit. p. 25

On a more optimistic note, it is interesting to note that external stimuli exist not only because of the competitive pressures building up and leading SMEs in particular but also big state companies to innovate, and World Bank programmes integrate more and more, an important component of capacity building in Science and technology. The new system in the Maghreb should be capable of harnessing the enormous potential of creativity at a more decentralised and population level, suddenly revealed paradoxically by the various crises resulting from the implementation of SAPs.

On a more conceptual level, increasing attention is paid to local and territorial innovation systems and governance institutions. On the innovation diffusion, the literature pointed on the network model (Cappellin, R & Nijkamp, P. 1990), that considers a competitive productive local system as characterized by a plurality of integrate relationships. In this model, evolutionary processes, as the building capacity of different local actors have a crucial importance. Also tacit knowledge, as a fundamental resource of modern productive processes, and interactive processes developing among different actors in the innovation process (Kline and Rosenberg, 1986, Mansel & When 1998, Rubenson & Schuetze 2000). Local productive systems are considered as places of collective learning where development can be stimulated through the creation of new knowledge implies an intense process of interaction, which is characterized by the transformation of tacit into codified knowledge and a movement back to practice where new kinds of tacit knowledge are developed. Innovation dynamics is linked to "multi-level governance".

This area in which we are orienting current research appear to present complementary ingredients to root firmly the innovation process into the dynamics or growth and development.

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