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«INSTITUTIONS AND KNOWLEDGE IN THE EUROPEAN SPACE INDUSTRY»

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1. Introduction.

After the failure, in the post WWII period, of the conventionalist ideas of Europe, it is the more pragmatic 'step by step' process of economic integration that led the european project. Thus, from custom union to monetary union, European integration has been primarily built upon market unification. The relative success of this negative integration process is probably due to its progressive feature and to the fact that it avoids to face directly the national sovereignty issue, in particular the social and economic regulation problem.

This market approach has resulted in the coexistence of (or conflict between) some historically prevalent, more or less centralized, national macroeconomic means of short term regulation and some more decentralized and structural ways of european market coordination. The conversion of the industrial policy notion in the seventies into a competition policy in the eighties gives evidence of such a process.

Despite the overall coherence between the micro and macro economic (monetary) levels that we can find in this economic integration, one can ask for a thorough insight into the institutional change issue. More precisely, we contend that national institutions used as regulators of domestic economies can not be solely replaced by European institutions in charge of competition on markets. Leaving apart here the macroeconomic coordination issue at the European level we would rather like to stress on the industrial side the importance of institutions in the emergence and dynamic of social capital[1] in the framing of an evolving industry.

As far as the discovery process of a market economy is recognized, institutions may have some role to play beyond their traditional mission of competition warrant. In particular, creation, transfer, and accumulation of knowledge might be an important part of any industrial dynamic. Institutions matter in that respect for as Metcalfe[2] noticed (i) they constitute the means to store and communicate information and the means to support particular patterns of interaction (ii) they embody the rules, the standards of socially agreed belief, (iii) they are the means to accumulate justifiably true knowledge in relation to science, technology, as well as organization and social discourse.

From a quite general standpoint two reasons, at least, lead us to cope with this institutional change issue. The first one is that, from an analytical level, markets are locus where economic interactions take place in which institutions matter, for they frame such interactions. Such a framing is not reducible to the state policy but refers also to normalization processes, financing modes, scientific interactions etc… We can here refer to the 'national innovative systems' literature[3] which has shown, on an inductive basis, how innovative activities are institutional dependent. The firm cognitive capabilities can, for instance, be modified according to the institutional setting [4]. This may happen to be of some great importance in explaining the evolution of firm competencies as institutions play an important role in the constitution and evolution of the social capital of an industry. Moreover evolutionary analysis has identified some conditions of state intervention in

[1] Social capital can be here defined as the combination of (i) social organizations as trust or norms ,(ii) social networks, (iii) information and knowledge channels. Cf. e.g. Dasgupta, Serageldin, 1999.

[2] S. Metcalfe 2000

[3] Cf.e.g. Lundvall 1992

[4] Cf.e.g. B. Loasby 2000

technological competitive diffusions such as narrow windows policies[5] which again foster attention to institutions in a evolving market economy.

The second reason consists in the inertial feature of any institutional dynamics. In so far as market integration enhances the competitive and change processes, the co-evolutionary institutional dynamics is worth thinking over. In the European context and from an economic point of view the question is not so how do deal with the sovereignty issue in industrial policy than how to adapt European institutions to evolving markets. We contend that traditional vision of institutional set up in competitive market falls short of an evolutionary economy.

Referring to an evolutionary appreciative methodology, we do believe here that inductive, historical studies can be of some help in exhibiting some analytical benchmarks on this institutional issue. In this perspective, we concentrate here our attention upon the institutional change that European space industry has known since the 70's. It could indeed be interesting, as many are asking for European agencies for industrial market regulations[6], to study a sector for which such an agency exist. This activity is characterized by (i) the presence of important institutions which where directly launched at a European level so that the sovereignty problem, though important, can be considered here as secondary[7], (ii) the development of high technologies and then considered as a strategic sector, (iii) some mutations that have been recently engaged under economic and technological pressures.

We are interested in the evolution of competencies in this sector[8] as a result of specific patterns of interaction between firms, markets and institutions.

2. From mission-oriented institutions…

The role of institutions, as the European Space Agency (ESA) and associated agencies in framing interactions between actors has been fundamental in the space activity[9]. In the seventies the main mission of ESA is to elaborate a European space policy and to coordinate european programs with national one. This is done through different programs divided into a scientific part with a financing duty and an applied part. This mission gave to ESA the possibility to drive all actors learning processes and then the development of competencies. This was possible because both the knowledge base and the coordination process were elaborated and controlled hierarchically by ESA. Two periods can nowadays be distinguished to characterized different patterns of interactions. The first one is of a 'mission-oriented type' and corresponds to a model of interaction where institutions adopt a top-down centralized approach in order to reach some objectives. The second, which is now emerging, is more 'cognitive-oriented'; institutions are more catalytic and provide some framework for the establishment of a self-organizing industry.

In a first period, during the 70's, institutions are the main actor in space activity for they are those who are able to conceive and launch complex systems. In this strong learning period, space activities are not coordinated by price mechanisms for the allocative perspective is not at sketch. It

[5] cf.e.g. Arthur 89.

[6] Cf.e.g. Cohen, Lorenzi, 2000

[7] This problem had been anticipated by the establishment of the fair return rule.

[8] Although a focussed analysis would need comparative studies with other industries, institutional changes in space activities have been sufficiently drastic and somewhere sufficiently exemplar from a knowledge perspective to deserve special attention.

[9] For a recall of those institutions cf. e.g. Bes, Rochhia 93

is instead a set of rules that is used in order to promote long term relationships between industrial actors. Transfers of knowledge in inter-firms cooperation were important in the construction of an industrial productive capacity. Industrial consortia such as COSMOS, STAR in the seventies are representative of the industrial organization at this epoch. Those agreements allowed for strong and specific learning processes to take place at each level in consortia. More precisely, prime contractors gained management experience in implementing complex satellite projects, co-contractors and sub-contractors gained experience in space sub-system technology engineering. A general knowledge base was created by institutions in all space areas and applied knowledge was created by industry on such a basis in a very linear top down fashion. Codification processes were then strong in order to insure transfers between the different levels while tacit knowledge was developed in communities of practices at each level. This led to strong learning processes at each level which enhanced specialization between payload technologies and platform technologies. Although ESA encourages the constitution of different consortia to maintain a competitive pressure upon firms in order to respect time and financial constraints, cooperation between firms was the rule.

Although the set of rules was conducive to the building of a coherent European space productive capacity, the 'fair return'[10] rule led to a geographic fragmentation of competencies. This has been an additive constraint to the already quite complex decomposition of the spaces projects. Indeed institutions went for a functional decomposition where agencies had conception tasks in charge, firms took production upon themselves, while States assumed marketing. Division of labor was achieved according to a technological and functional logic founded upon a distinction between systems and sub-systems. Prime contractors were responsible to ESA both contractually and in all technical matters. They allocated work both to co-contractors –particularly to payload co-contractors - which were responsible for individual satellite subsystems and to subcontractors which supplied equipment. This separation clearly led to distinct competencies between platform and payload applications. Connection of competencies seems to have been complicated by this separation as well as by geographical considerations. The overall coordination process has nevertheless been supported by institutions which developed real competencies in coordination tasks and accumulated huge knowledge in all space areas.

It is worth noticing that the construction of a European space activity has been founded on acquisition of new different competencies apart from any commercial conception. Cooperation and rules, in a 'technology push' vision, led agencies to technological exploration while at the same time firms began to seek for commercial exploitation of accumulated knowledge and competencies.

This 'technology push' approach was in line with a very specific notion of market. Indeed market prices did not exist for an independent demand was absent. Instead mark-up prices composed of industrial costs and margins were used and industrial commitments were taken on economic and technological targets. Finally it was the sharing of risks that led the logic of institutions regulations.

This overall cooperative and technological conception of space activities has been promoted and diffused by institutions and rapidly adopted by all actors. This shared representation framed the knowledge and learning trajectories both at individual and collective levels in such a way that ex-ante coordination of actions was favoured. We meet here the general idea expressed by Loasby according to which institutions encourage the emergence of mental representations and of similar procedures among actors and reduce costs of transactions for ideas. (see fig. 1)

This industrial organization will nevertheless prove to be very inertial in the 80's when commercial applications began to grow. Institutional exogenous incentive scheme became threatened by market

[10] the industrial and technological return in each state is proportional to its financial contribution

incentives. Path dependencies as much deeply rooted in individual and collective routines (cognitive traps) as in industrial relationships were an impediment to rapid adaptation to the growing markets. Specialized application markets necessitated to take into account specific uses in order to define specific satellite missions (e.g. telecom mission). Prime contractors from the previous period had no competencies in such a task and a drastic reorganization of the sector was needed to integrate sub-systems competencies to core competencies. Finally under political pressure institutions, in particular ESA, drove this evolution in destabilizing the former consortia approach. By the late 80's COSMOS, for instance, has been transformed into an exchange information club.

The process was all driven by the idea of transferring space commercial applications to national or international operators. This in turn gave life to new interaction patterns within the space activity. Firms which were previously confined in payload sub-system had the opportunity to participate directly to the management of space projects. Prime contractors were then forced either to acquire new competencies in payload technologies or to find some niches where they could not be easily challenged by new entrants (e.g. optic).

One result of such a process was that firms had to support more risks and failure costs. They then developed some competencies in risk management and sought for low costs in encouraging economies of scale. Industrial reorganizations through alliances were at sketched and the previous fragmentation of European space activities began to be reduced. As a market logic began to appear during the 80's, the economic role of institutions, which appeared a bit tentacular, was strongly questioned.

3 - … toward cognitive oriented institutions

European space institutions are facing a coordination problem. First, there still exist a potential tension between national agencies and European ones. Second there is a R&D policy tuning to find between ESA and EU. This institutional coordination issue sends back to the very definition of the mission for space agencies. As we have seen, until the eighties agencies played a major role in defining technological trajectories and in arranging institutional markets. When commercial opportunities were pointed out the previous hierarchy in actors had to change. In particular, the 'co-determination of use' process appeared to be far reaching in industrial organization. Strong feedbacks from payload technologies to platform conception strongly weakened prime contractors. As noticed by Atzei and Pseiner[11] "one thing that is increasingly apparent (long recognized in other industries) is that a change in perception of just who the users are is required".

Along with this process was a change in the firms' business representation - in particular the technological conception supported by agencies and consortia did not drive their learning processes anymore. The dynamic of competencies within firms became framed by new patterns of interactions. Nowadays technological inter relationships between firms are frequent and horizontal overlapping coordination of this sector tends to overcome the previous vertical specialized coordination.

The appearance of those new interactions implied a redefinition of the role played by agencies. After a period of inertia in the early 90's, drastic changes in ESA' industrial policy was decided at ministerial level. Thinking was far reaching and went far beyond the recurrent issue of the fair return principle. ESA had to be settled down in the current pattern of interactions and some strong evolutions were proposed.

[11] Atzei, Pseiner, 97.

World wide competitiveness of the European space industry constitutes the main target. Intermediate targets are based on (i) cost reduction in access to space in general, which implies among other things a more efficient manufacturing processes, a cost reduction in small missions, synergy with defense and industrial initiatives, (ii) broadening space utilization and promoting large diffusion of space technologies, (iii) innovative behaviors - in particular in technological frontiers such as biotech, energy sources etc…- in cooperative networks largely open to SME's.

Horizontal coordination of public and private actors in a high-tech market-oriented activity implies large transfers of knowledge and competencies from agencies to interested firms. Beyond space activity itself and privileged defense and telecom applications, many areas can be interested by space technologies. Earth observation services, for instance, may have many potential applications in such different fields as agriculture, urbanization, environment, transport management etc…..

In the development of such interactions, institutions have to insure some leadership in the constitution and dynamics of the industry social capital. This social capital implies first the construction of networks composed of both public and private actors that share the same representation of the potential markets for space technologies.

It is however essential to notice that this shared representation must not be imposed by any actor (institutions e.g.) but must be an emergent property of patterns of interactions. This in turn does not mean that institutions have no role to play. They must facilitate such a process in (i) organizing knowledge transfers between all actors, (ii) maintaining some long term diversity in scientific and industrial programs, (iii) participating, along with market, to selection processes in order to avoid inferior technological trajectories. We shall examine now those three points with special focus on the first one.

In a knowledge perspective, we can interpret some ESA programs as being adequate tools for fostering industrial global interactions. ESA has, for instance, developed some programs such as EMITS[12] in order to allow interested firms to identify competencies and knowledge within networks. This clearly lead toward a 'co determination of use' in space technologies. Indeed SMEs of any industry can access to the network knowledge and determined if a technology transfer is feasible. ESA has set up a special SME initiative with the aims of enforcing interactions between traditional industrial actors and innovative SMEs[13]. Furthermore, as the space activity has been for long dominated by large firms it was important to think diffusion, technological transfers and innovative behaviors through high tech SMEs in order to preserve diversity of potential innovative trajectories. Today SMEs , be they in space activities or not, are then invited[14] through EMITS to submit innovative projects which imply technological transfers towards new uses. Medical observations and software have already proved to be interesting fields of such transfers and adaptations and many other domains can be envisaged. For instance it has been recently recognized that the scientific problem of dropping a potato crisp into a bag without breaking it is conceptually similar to landing a space craft safely[15] !

The construction of such a social capital also supposes that transfers of previous huge accumulated knowledge and competencies are organized between actors. Technical and scientific issues - though important in order no to reinvent the wheel - are not the unique aspect. One can notice that firms formulate needs in terms of commercial products and services which means that technological push or determinism tends to be replaced by co-determination of supply and demand.

[12] Electronic mail invitation to tender system
[13] cf. Brisson and al. 2000.
[14] There are about 5000 individual active users
[15] cf. Brisson and al. 2000

Knowledge transfers become then a strategic variable for it is the basis for a common business conception. Moreover the low cost objective rapidly demonstrated the importance of the initial conception steps, for they determine about 80 % of future expenses[16]. Damage survey of any failure in the decision making system at all levels is of great importance in cost management. In the same perspective organizational memories and knowledge management programs have been launched by institutions. In a first step those information and communication programs, such as data warehouses, meta databases, groupwares etc.., necessitates a detailed survey of knowledge architecture within the institutions and must take into account the many shapes of knowledge to avoid information fallacy. We can guess that in a second step those tools will be of easy access for external actors and will contribute to creation of new knowledge[17.] Making such knowledge available in a convenient and structured manner to industry, research institutions and other actors would indeed constitute both a valuable return on their investment for ESA's member States[18] and a conducive mean to the emergence of a renewed shared vision business conception.

European space institutions, as we noticed, are now owners of long experiences in complex project management. They developed, for a long time, tools of problem solving and knowledge capitalization. However until recently attention was only paid to technical experiences and no distinction was made between explicit and tacit knowledge. The overall process was driven by a data access issue and no consideration was paid to potential organizational consequences.

In this context, only explicit knowledge was stored, that is the results of interactive processes or experiences and not all the set of abandoned ideas, propositions or even conflicts that characterized the evolution of complex projects. It is however duly recognized today that knowledge capitalization can not be reduced to a data access problem[19].

Quantitative approach in such a matter may indeed hide some fundamental issues such as codification, modes of knowledge transfers, learning processes understanding etc…. As Nonaka noticed it may appear that the very nature of accumulated knowledge is not independent from the different modes of transfer. The well-known distinction between tacit and explicit knowledge implies, for instance, numerous questions about storage and diffusion. In this perspective new programs of knowledge management have been undertaken within European space institutions.

Contrarily to previous information program, new systems as Corporate Knowledge management study or ESA lessons learned systems or Keep ID are integrated in an overall organizational vision. As noticed by some ESA scholars [20]'knowledge management is often confused with document management and the fact that most knowledge circulating in an organization is never captured or documented is overlooked'. Furthermore economics and knowledge management rely on some organizational conditions among which individual mental representations, governance and incentive structures, leadership and financial measures play an important role. The objective is to create a favorable environment through knowledge management in order to promote (i) help to problem solving and decision making, (ii) knowledge and competencies maps (iii) transfer of tacit knowledge in providing pointers to individuals who possess knowledge and competencies. All those tools constitute important vectors of information and knowledge networks for industries that shall enhance interactions and contribute to the rise of social capital. As well known, information and knowledge transfers have positive externalities which generate appropriation and incentive issues, creating a role for institutional investment in creating social capital.

[16] Alcouffe, Bes 1999.
[17] For a characterization of knowledge in technological agreements cf. e.g. Lazaric, Marengo 2000
[18] The fair return principle may then include immaterial services.
[19] Cf.e.g. Cohendet llerena 99.
[20] Raitt and al. 97

Maintaining some diversity and participating to selection processes constitute an other important role for institutions in implementing an evolutionary space policy. Let us first remark that over the last years, space industry in europe has known a very important restructuring process. Large companies that can act as prime contractors are few as a result of mergers. Vertical integration has been increased to take into account payload issues. On one side competencies dispersion has been reduced, lower costs are targeted and market applications are taken into account; economic efficiency is increasing by exploiting current knowledge and competencies. On an other side one can wonder if such an industrial organization does not constitute a potential threat to SMEs and if it is conductive to innovative behaviors; is evolutionary potential decreasing? This question makes as much sense as we know from evolutionary literature that in closely coupled organizations there is far less scope for individual creative behaviour than in more open, loosely coupled organizations. There might be a real danger to go from a institutional centralized dynamics to a vertical integrated large firm dynamics for 'good economic reasons'.

Preserving an evolutionary potential, that is some diversity in space activity, might be of some importance . Apart from traditional long term scientific research and own technological programs, institutions, as Atzei and Pseiner[21] remarks, have to "maintain a correct balance between large prime contractors capable of competing on the world-wide market, sub-system equipment suppliers with unique expertise, and a network of innovative SME businesses." This can be achieved by providing large technical and financial support to High tech SMEs in a risk sharing fashion for pre competitive R&D phase. Selection processes coming from markets, technological and organizational spheres can then eventually be complemented by catalytic narrow windows interventions aiming at avoiding lock-in into inferior trajectories.

4- Conclusion

Although commercial applications are still not dominant in space activities[22], institutional changes have been undertaken in order to let new patterns of interactions take place. A 'co-determination of use' logic in a market-oriented perspective allowed strong feedbacks from payload firms to space project conception phase insured by institutions and prime contractors in a quite hierarchical fashion. Previous distributed and specialized learning processes have then been modified leading to changes in the knowledge bases and competencies of 'near to market firms'. The important restructuring process that followed led to vertical integration in the industry but also allowed new entrants with commercial ideas to come. Meanwhile the coordination scheme previously insured by institutions evolved from a centralized mode to a more decentralized one. Shared representations of space activity went from 'scientific and technological determinism' promoted by institutions to 'co-production of use' determined by numerous interactions.

Ordered patterns of economic change need however to avoid a too far institutional retrenchment. First evolutionary potential have to be preserved: SMEs networks have to consolidated. Second, institutions - apart from their still traditional scientific missions - have to promote the consolidation of an industry social capital in facilitating technical, economical and organizational knowledge transfers. In this perspective all current knowledge management programs within institutions should not be developed for internal use only but have a strong external cognitive mission. Space industry would probably gain in a much more spread horizontal organization, taking also into account, services and technologies as business units. The development of networks with private and public actors is not the only issue here, for connectivity is a necessary but not sufficient condition for

[21] Atzei, Pseiner, 97.
[22] It represents about one third of global activity

shared representation to emerge. Receptivity of actors is also probably needed, as much as complex knowledge is concerned. This issue would probably need further attention.

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