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Different frameworks for rationale, modalities and evaluation of public intervention in research and innovation: traditional and innovative aspects in the example of space agencies

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DIFFERENT FRAMEWORKS FOR RATIONALE, MODALITIES AND EVALUATION OF PUBLIC INTERVENTION IN RESEARCH AND INNOVATION: TRADITIONAL AND INNOVATIVE ASPECTS IN THE EXAMPLE OF SPACE AGENCIES

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Abstract

Neoclassical paradigm, evolutionary theory and the theory of intangible assets are utilized to analyse reasons, modalities and evaluation of public intervention in research and innovation, in general terms and in the concrete field of space activities, with a particular focus on the Italian Space Agency.

1. Introduction

The neoclassical theory has deeply analysed the subject of public intervention in research and innovation activities, justifying it in the light of the market failure theory: the same theory suggests possible solutions to the problem of private underinvestment in these fields. The evolutionary theory of innovation, and particularly the paradigm of national systems of innovation, sheds new light on the institutional aspects of the problem, underlying the need for a collaboration between different institutions. The recently rising theory of the intangible assets conceptualises these themes in a new and comprehensive view, also enlightening new problems.

In this paper these conceptual frameworks are seen only briefly in an abstract and theoretical way, but their analysis becomes more concrete and precise focusing on a particular sector with a strong need and rationale for public intervention, aerospace, and on the peculiar instrument of public intervention in this field, the public space agencies. The specific object of analysis is the Italian Space Agency, whose policies are analysed in detail, clearly referring to the national context.

Even though the case is specific, conclusions are more general, underlying the urgent need for evaluation of public action and considering the new perspectives given by the intangible assets theory.

Par.2 analyses the main reasons and instruments for public authorities to intervene in basic and applied research. It considers the reasons that traditionally justify public intervention, such as market failures, and the traditional policy instruments, like patents and subsidies, but it also focuses on modern instruments, like policies directed to favour the interactions between the actors of the innovation system. Some difficulties for the concrete application of these policies are also considered. These concepts are also seen in the light of the intangible assets theory even considering the increasing importance of the social capital; we consider this concept as the ability of a firm to develop interactions with other firms and the university.

In the light of this framework the space sector is taken into consideration (par.3), trying to understand in which ways the general framework is valid for this sector. For this purpose its peculiarities must be taken into account too, such as its strategic importance for national prestige and infrastructure and the relevance of its spillovers to other sectors.

This analysis is conducted illustrating the action of space agencies, trying to analyse if and how their concrete activities could be conceptually related to the policies considered in the general framework.

In order to make the analysis more concrete and specific, the case of the Italian Space Agency is considered (par.4), also with some parallels with the European Space Agency and the National Areonautics and Space Administration. This analysis may be divided in two parts: what is financed and the modalities of financing.

Therefore the different programmes of the Italian Space Agency are briefly illustrated: programmes of basic and applied research in space activities, programmes of technological development, research in telecommunication and earth observation, programmes of technology transfer, etc. The paper also analyses the selection process in the choice of the project to be financed and the difficulties related to this choice, the relevance of the interactions between the different institutional actors and the attention directed towards problems of local development in localisation decisions. An innovative perspective regarding the possibility that an “excess” of intangible assets becomes an intangible liability is also introduced.

Par.5 contains a summary of the policies implemented by the Italian Space Agency and some further considerations. The activities of the Italian Space Agency, and more generally all the policies directed to sustain research and innovation, are divided into activities that may be justified with the traditional concepts related to market failures and more innovative policies that may be related to the conceptual frameworks of the national innovation systems and the knowledge economy.

Some considerations about the evaluation of technology policy follow. The complicated problem of public policy assessment becomes even more difficult if spillovers have to be taken into consideration. Some methods suggested in the economic literature are reported, but it remains the difficulty of gathering empirical evidence on such spillovers, that is a sign of the need to develop our understanding of knowledge diffusion and creation in network.

Par.6 tries to link explicitly, even if briefly, the considered issues with the theory of the intangible assets.

2. Rationale and modalities of public intervention in research and innovation.

Research and education have been considered as different concepts by the economists. Even though R&D and human capital are both “intangible assets”, there is a clear distinction between them. Anyway both of them represent stocks of knowledge and both have the economic characteristic to give benefits not only to the agents (firms or individuals) that invest in those assets but also to the others that benefit from spillovers. This is the reason because the scholars of the new growth theory have considered these two factors as the engines of the growth, through the technological change (see Romer, 1996, for a review). Therefore the rationale for public intervention in the two fields is similar. The attention towards education[1] came first, so we can begin our enquiry on the rationale for public intervention in R&D, that is the main focus of this paper, referring to the rationale for public support to education.

Even in the thought of the pioneer of the *laissez-faire* theory, Adam Smith, some functions remained reserved to the government, like education. Though education was a good or a service that could be provided in the private market, the father of the modern economic theory evidently identified the possibility or the certainty of what the “economists of welfare” would have called “market failure”: the matching of demand

[1] The concept and term of human capital is relatively recent: the idea that it is possible to invest in education, by which the term derives, has been explicitly advanced by Gary Becker (1964).

and supply at a market level would be fixed at a too low level to satisfy the social need of an average high level of education[2].

The education of single individuals is indeed a collective benefit: the economists of growth formalized this process but the link between the level of education of the population and the ability of a country to economically grow was long ago known.

Obviously education is also a natural right and therefore it cannot be limited by an insufficient availability of means: this implies the need to take the education away from the pure private market laws.

This primarily regards the lower levels of education that, just as social need but also inalienable right, become also a duty and therefore education become compulsory up to a certain age.

This is anyway also valid, *mutatis mutandis,* for upper education and university research in particular: research is a resource for the whole nation and, being such, it cannot be provided by private supply only, that would not be enough. Economic theory rigorously supports this claim.

In fact, university research is in charge of advancing the knowledge frontier and diffusing such advanced knowledge; such activity is surely beneficial to the entire community, but the benefit is difficult to evaluate. It can be argued in any case that the benefits exceed the private returns: education generates externalities and therefore the private return is lower than the social one. The consequence is that public intervention is required, even in fields that are apparently or really far from an immediate economic application.

From the researcher's point of view, it is true that he is often urged by a not exclusively economic interest, but it is difficult that the simple satisfaction for having improved the knowledge could adequately compensate him for the effort and time spent in the research.

There are of course fields of pure research where the link with the economic effects is clear and direct, but even there a market failure exists: the benefits of pure research become economic effects only after a complicated process, so that the distance between the researcher and the economic consequences of his research is often very large (even following the traditional, linear "paradigm" of the innovation process, scientific research needs a long phase of technological development before being economically exploitable). Therefore the researcher cannot appropriate, if not partially, the economic benefits of his research.

The problem of the appropriability of the results is equally great if we consider the results of technological research, that is clearly addressed to a practical utilisation: the results of a specific research programme are useful for the other firms belonging to the same industry of the innovating firm and they can have spillovers and applications in several other sectors and contexts. If the innovator (generally a private firm) cannot entirely appropriate the results of the research, his incentive to innovate will be lower than the collective benefits generated by the research. The result is underinvestment in R&D relative to the social optimum, to which the need for public intervention follows.

[2] Adam Smith treats this argument in the fifth book of the "Wealth of Nations" (1776). He obviously does not formalize the concept of market failure, but he identifies a series of public utilities of the education, particularly, in truth, of an exclusively moral nature, that could not be reached without a public intervention.

A study by Levin and Reiss (1987), considering the United States economic system, confirms empirically the existence of a link between the degree of spillovers and the likelihood of government support.

From what we have until now said, it is evident that the rationale of public intervention may be conceptualised in the light of the intangible asset theory. If “knowledge generating production”, as intangible assets are currently defined, -including in this term not only R&D but also human capital, advertising, marketing, etc., (Mahony – Vecchi, 2002)- is the base for economic advance (Romer, 1990), it is obvious that government should concentrate its effort in this field. But this remains a generic statement and there is some imprecision in the definition of intangible assets. The old Solow’s concept of residual is still useful: there is a part of output growth that is not explained by changes in factor inputs. Intangible assets are those factors that can explain such residual. Looking at a firm level, expenditure in R&D in human capital and the other factors seen above give an important contribution to explain the “residual”, but the empirical analysis reveals that an important contribution is given by R&D expenditure made by other firms (Mahony – Vecchi, 2002). Therefore the analysis conducted at a firm level confirms the existence of large R&D spillovers. As they contribute to explain the residual, they can be considered as intangible assets themselves and, as they have the nature of externalities, the public intervention is traditionally justified.

Public intervention to increase R&D investment takes various forms. One form is the institution of the patent system, that tries to remedy the problem of the public good nature of knowledge that underlies technological innovation (Arrow, 1962), increasing the appropriability of the innovation, that anyway is never complete, partly because other distortions may result (for instance, monopoly prices).

An alternative intervention is the direct financing of research, through R&D programmes for instance. This modality of intervention also incurs problems, especially of informative nature: there is information asymmetry between the public authority that finances R&D and the private beneficiary of the funding, that may result in wrong financing decisions or even to an opportunistic behaviour of the funding beneficiary. It is also possible that private investment is crowded out (Torrisi, 1997).

In addition, capital market imperfections should not be ignored, since they can generate financing problems even in the case of perfect appropriability of the research results. The high uncertainty inherent in innovation projects may lead to the impossibility of finding investors.

Another argument must be added: among the reasons that induce the government to increase research, there are also considerations of international competition, not only in terms of economic growth but also of prestige: a Nobel prize, to make a simple example, perhaps does not give an immediate, measurable advantage to the country which the awarded belongs to, but surely increases its international prestige.

All the above considerations imply the necessity of public financing of scientific research.

However public policy is not restricted to only a matter of financing. The evolutionary theory stresses the importance of the institutions and the National Innovation System concept changed the current view of the tasks and tools of the technology policy.

In the neoclassical paradigm information is complete for all the agents and prices include all the relevant information; therefore there is no friction to the circulation of goods and knowledge. Institutions cannot really influence the economic systems. The framework implemented by evolutionary economists is quite different; they build their paradigm on the concept of bounded rationality and the existence of non-price relationships. In this contest innovation becomes an interactive process and institutions and organizations “may change things”. The different nature of institutions between them and across different countries, the different interactions may deeply influence the creation and diffusion of innovation. These concepts are the bases for the National Innovation Systems framework[3]. It particularly stresses the importance and the different results generated by the different ways institutions are shaped and interact. The scholars of NIS underline both the different results generated by a different way of interaction between university, industry and government and the crucial importance of an established and constant interplay between these three main innovative agents. The advent of this conceptual framework of course did not preceded the existence of continuous and established contacts between these institution but it surely increased the attention toward these topics and to the need of creation of innovative networks, on a global and local level. But, after a promising beginning, the students belonging to this framework are failing to give a deep understanding of the functioning of such innovative networks. New sophisticated instruments are required and some intellectual and academic bridges have to be crossed. Anyway, some practical results have been obtained. Many governments have produced a great effort in increasing such interaction and networks. USA are probably leading this “race”, having implemented interactions between university and industry (the Bayh-Dole Act in 1984 was an important legislative turning point), but the NIS framework is becoming the guideline of the current European technology policy.

It is possible to see this issue in the light of the intangible assets framework. In an economy where learning and crossing bridges become fundamental capabilities, the new basic “intangible asset” for a firm and for the economy is the ability to create and absorb technologies through interactions of firms among them and between firms and university (Bianchi, Labory, Iorio, Malagoli, 2002). This capability, as it is subject to an accumulation process, may be called “social capital”.

It is now clear that public policy also include the need to favour the correct functioning of the institutions that have research as their goal, as well as to encourage the interaction between the other actors of the national innovation system (university and industry, while government is the third fundamental element): policies directed to favour the interaction between university and industry are on the top of the current policy agenda (European Commission, 1995).

Moreover we have to remind that the support of demand in those sectors that are fundamental for the technological advance of the country is another goal of public intervention, as well as the support to the supply side, especially regarding new firm creation.

Last, another goal of public intervention in research might be the need to correct territorial unbalances, sustaining innovative activities in backward areas.

[3] For an exhaustive and recent review of the National Innovation System concept see Lundvall *et alii*, 2002.

3. Public policy and space agencies

It is possible to find a concrete application and immediate check of these considerations studying those public agencies specifically dedicated to the support of scientific and technological research, like national and supranational space agencies.

United States, Canada, several European countries and the European Union as a whole have a space agency[4], whose goals are to favour scientific and technological research in the space sector, to allocate public funds for this purpose and to co-ordinate activities of research and commercial application of technologies developed in the space ambit.

What are the motives for setting a public agency? The considerations made until now help to give an answer.

One important point is that the space sector is an ambit where an important international competition has been played and is still being played, especially in terms of the prestige mentioned in the last section, with particularly harsh characteristics in the period of the Cold War. Competition is today perhaps less hard, but the space sector remains a very important field of comparison of the technological level reached by the different countries.

Several studies (see, for example, Guerrieri - Milana, 1998) confirm that high technology industries are the base of a nation long-term economic performance, mainly because they generate externalities, and of the international competition (the so-called technology race).

Moreover the space sector generates a series of spillovers and application in the military context and this is certainly fundamental to justify a public intervention: defence is historically one of the state tasks. This is also justified from an economic point of view, as it is a pure public good. Bagliano-Bertola (1996) in their review of growth theory remind that public and quasi-public goods are themselves engines of growth, even regardless of the sustain to technological advance.

Another traditional task for the state, justified at a theoretical level with the concept of market failure, is the intervention in the creation of infrastructures. This concept refers not only to traditional structures, such as transport facilities, but also "immaterial" communication structures, such as telecommunications or the even more modern tools of satellite navigation systems. These are the fundamental "technological infrastructures" on which a great part of the competitiveness of an advanced economy is based. Airspace research generates large spillovers precisely in these fields and this is a further justification for the particular attention paid by government to this sector.

Even in this case the justification for public intervention is a market failure: the social benefits granted by transport and telecommunication systems, protection of environment, etc. are largely above private benefits. Therefore, it would be very difficult, probably impossible, to find a private entrepreneur that would invest in such activities. In these fields, therefore, government provide the public good. It may

[4] European Union has not definitely a Space Agency, as the European Space Agency is not the EU space agency: it was invented in 1973 and begun work in 1975 to combine the aims of the former European Launcher Development Organization and the European State.

produce it, through public enterprises, or purchase it from private enterprises. The second one is generally the case in activities linked to the space sector. From this it does not necessarily follow that government should finance even R&D activities. But it is evident that, as government is interested in results of research, being the main or the only purchaser, it also sustain research in space sector (Mansfield, 1969).

An important characteristic of the aerospace activities are the strong spillovers on other industrial sectors. This is due to the fact that space research is not limited to the mere scientific ambit but has a very large technological component. It is in fact obvious that sophisticated technology is required also for pure research purposes: for instance, the studies conducted on the origins of the Universe require theoretical models but also, to verify such models, the observation of the cosmic rays, that can be done only with advanced technologies; orbiting a satellite or space shuttles with men aboard clearly requires a very advanced technological research.

Another example of spillovers is the research on materials, that is crucial for satellites: such materials have proven to be extremely useful for other sectors, in particular the medical sector, which is one of the several and most socially important examples (for a synthetic but complete framework of the possible technological spillovers of the space research see Ramaciotti, 1999).

This characteristic of technological research in the space sector represents a powerful justification for public intervention: the benefits obtained by a single firm which develops a product in the space ambit are certainly less than the benefits the economy as a whole may obtain; in the absence of institutions that allow a perfect appropriability of these results, it is obvious that we are facing clear externalities, that may be corrected only by public intervention. This justifies the financing granted by the government, through the space agency, to firms operating in the space sector for projects of R&D that may have significant spillovers on other sectors.

Marengo – Sterlacchini (1990), in their study on intersectoral technology flows in United States, United Kingdom and Italy, confirm that aerospace sector is largely pervasive, at least in the first two countries (the sector was too small in Italy to be explicitly considered), generating a large amount of intersectoral technology flows. In any case, it must be reminded that in an old but fundamental study on the space activities in the USA, Mansfield (Mansfield, 1969) underlines that such spillovers alone would not be enough to justify the large amount of public expenditure in aerospace activities.

The spillover concept could be applied to the acquired knowledge too: know-how is developed through the research on a specific project which is then transferable to other fields.

Moreover, a widely shared consensus in economics is that the increase of R&D within a firm makes the absorption of the innovation coming from other firms easier (Cohen – Levinthal, 1989).

The above discussion makes the rationale and main actions of a space agency clear: on the one hand, the space agency identifies research lines in the space ambit and finances universities and research centres that conduct this research (many space agencies do not have their own research centres), obviously through an appropriate selection process. On the other hand, the space agency also identifies the guidelines of the technological research that is conducted in academy and industry. In fact the government has a role not only of financer but also of main purchaser, since space technologies are of a great public use.

Despite this predominance of public demand for space technologies and research outputs, private demand has been significantly growing: the share of private demand for European space agencies exceeded the share of public demand in the year 2000, while private demand represented only 54,6% of public demand in 1996 (Eurospace, 2002 – see Table 1).

Table 1 – Customers of the European Space Industry from 1996 to 2000

Consolidated turnover **Distribution by customer**	**1996**	**1997**	**1998**	**1999**	**2000**
ESA	1835.0	1501.0	1674.0	1520.8	1529.5
National civil programmes	467.0	794.0	617.0	754.3	653.7
National military programmes	519.0	383.0	512.0	521.8	405.5
European commercial contracts	45.0	14.0	17.0	16.9	57.6
Sub-total institutional customers	**2866.0**	**2692.0**	**2820.0**	**2813.8**	**2646.3**
Commercial sales	987.0	1450.0	1524.0	1647.2	1804.0
Arianespace contracts	578.0	943.0	931.0	976.2	1061.6
Sub-total Commercial Customers	**1565.0**	**2393.0**	**2455.0**	**2623.0**	**2865.6**
Other contracts (or unknown)	124.0	61.0	42.0	44.0	48.8
Total Europe	**4555.0**	**5146.6**	**5318.5**	**5481.2**	**5560.7**

Source: Eurospace (2002), pag.8

Space agencies also have an active role in contributing to the development of less advanced areas.

After having seen the fields of intervention of a space agency, methods remain to be analysed. We have seen that universities, research centres and industry are the points of reference of a space agency. These are the fundamental actors of an innovation system: government (trough the space agency), industry and university (and research centres); as it is known from the literature on this subject, the characteristics and even the success of an innovative system depend on the ways these actors interact. Therefore we have to analyse how the space agency regulate the intervention of the other two actors in the innovative process and how it favours their interaction.

In the previous paragraph we saw the increasing importance of such interaction. Indeed, this may be considered the future specific role of a public agency. More then allocating resources, exploiting the intangible assets potential of firms and universities should require nowadays a specific attention, particularly regarding the social capital of those agents, because this need is increasing but it has been only recently recognised and therefore agents could not have enough capabilities in this sense. Considering the activity of a public agency in this light would therefore require a deeper understanding of concepts like intangible assets and social capital.

Referring to a more consolidated framework, we remind the distinction between *mission-oriented* and *diffusion-oriented* policies and innovation systems (Ergas, 1987). Mission-oriented countries give primary importance to international strategic leadership; these countries develop great research projects, with a high level of concentration and centralization of decision-making; they have a large share of defence expenditure. Concentration also extends to technology: R&D funding in these countries is biased towards a few industries, generally in the early stage of technology life-cycle. Government agencies for technology policy play a great role and have a large discretionary power.

Diffusion-oriented countries aim to provide a broadly based capacity for adjusting to technological change, rather than introducing radical innovations. The industrial structure of these countries is largely based on small and medium size enterprises. These systems are largely decentralized and public agencies have a limited role. A great role is instead covered by investment in human capital, which can ensure the absorption of new technologies. The same goal is detained by government institutions (like the famous German Fraunhofer Gesellschaft) for technology transfer and by extended collaboration between institutions.

It is evident that, as Ergas himself emphasized, this is a rough distinction and that each country has policies of the two types, even though the main focus of national policy makes this distinction significant. Surely space activities are mainly mission-oriented, but the relative decline of military goals and the increasing “market vicinity” of some space technologies (Cantner – Pyka, 2001) are, up to a certain point, changing their nature, posing a greater emphasis on their capacity to generate spillovers. But this emphasis and this capacity largely depend on the national innovation system and policy orientation. Therefore, it may be interesting to evaluate the actions of a space agency in the light of this taxonomy: if it is evident that space activities are oriented toward technological innovation, it remains to verify how much space agency actively operate for the diffusion of such innovations.

From what we have until now said, we understand that it is possible to identify kinds of intervention that have a well-established theoretical justification (like research funding) and others that are the heart of contemporary debate (attention to *spillovers*, to collaboration between innovation actors, active role in technological transfer process, etc.).

As we have said, many of economically advanced country have a space agency. Therefore it would be impossible to analyse the action of each of them or only to give a general framework, because we would face the differences between the agencies. For this reason our observation will concentrate on a single case, the Italian Space Agency (Agenzia Spaziale Italiana: ASI), but having as a term of comparison, at least for some aspects, the European Space Agency (ESA), whose activities, as we will see, European Union agencies, included ASI, are called to participate to, and the American space agency (National Aeronautics and Space Administration: NASA).

4. Modes of intervention of a space agency[5]

The Italian Space Agency was born in 1988. It belongs to the Ministry of Education, University and Research and it has the institutional function to promote, coordinate and conduct the national space activities.

The importance of ASI in the framework of national research is proven by the fact that it receives the 3.6% of total funding in R&D, included private investments (1992 data: Gambardella, 1997).

On the other side, it must be underlined that the dimension of the aerospace sector, that is quite limited in the whole Europe, is particularly small in Italy. Even though Italy is one of the main contributors to the European Space Agency, the international position of Italy is quite weak in the industrial aerospace sector: the ratio of Italy exports to total word exports in high-tech aerospace products is 3.4 between 1990 and 1992, while this figure is 10.8 for United Kingdom, 11.1 in Germany and 12.0 in France (USA are absolutely leaders, being their figure 40.1; EU 12 as a whole has 42.7) (Guerrieri – Milani, 1998). Anyway, this weakness concerns all the high-tech sector in Italy (Malerba, 2000).

We said that a primary task of space agencies is to coordinate and to finance research in the field of space activities. As we have seen, space activities may be distinguished in scientific and technological ones. Therefore ASI has distinct programmes in the two sectors. Anyway it must be right pointed out that, particularly in space sector, the two concepts are strictly linked: as it has been said, scientific research cannot be conducted without the help of adequate instruments and, on the other side, scientific research is the base for technology. It is therefore useful to make a further distinction, between basic and applied scientific research: the first one need a further development to have an industrial application.

Talking about ASI research, we have to state first that part of its decisions are bounded, in the sense that there is a compulsory participation to some ESA programmes and taking part in other several programmes is facultative (ESA allocated 79,4 Meuro to compulsory programmes, 221,2 to facultative programmes in 2000).

Table 2 shows the division of funds for programmes in quinquennium 1998-2002, as it is established in the National Space Programme 1998 – 2002[6].

[5] Information contained in this paragraph come from:
- Internet site of Italian Space Agency: www.asi.it;
- Internet site of European Space Agency: www.esa.int;
- Internet site of National Aeronautics and Space Administration: www.nasa.gov;
- Italian Space Agency (2001) and Italian Space Agency (1997).

[6] National Space Plan (Piano Spaziale Nazionale) is a programming document that ASI is obliged to publish every five years, to show the main lines of conduct it is going to follow in next five years.

Table 2 - Division of funds for programmes in quinquennium 1998-2002
(in milliard lire)

PROGRAMMES	Current programmes	Compulsory ESA programmes	New programmes	Total expenditure for programme	Commitment for 2003 and following years
Basic research	69	540	735	**1344**	0
Space Station	1318	0	40	**1358**	267
Telecommunication	220	0	580	**800**	0
Earth observation	379	0	835	**1214**	70
Launch systems	365	0	430	**795**	0
Technological R&D	105	100	610	**815**	0
Education	0	0	20	**20**	0
General expenses	254	135	15	**404**	0
TOTAL	**2710**	**775**	**3265**	**6750**	**337**

Source: National Space Plan 1998-2002, pag. 52

In the field of scientific research, ASI finances programmes in five distinct areas (in brackets there are some examples inside a single study area):

- sciences of he Universe (exploration of the characteristics of the Universe trough satellites);
- planetary exploration (probes toward Mars);
- earth sciences (physics of the atmosphere – meteorology - geology);
- life sciences (role of gravity in biological processes – behaviour and adaptation of man in the space – life on other planets);
- sciences of engineering (space systems of telecommunications – microelectronics).

As it is immediately understandable, to develop those scientific programmes it is necessary an adequate and very advanced technological support: indeed what are called “scientific programmes” are often proposals of basic technology researches (*general purpose* technologies).[7]

Besides, as we have said in the introductory part, many of the technologies developed to realize scientific programmes have spillovers in strategic sectors of national economy, especially in “immaterial” infrastructures. So, planetary exploration requires a great development of telecommunication technologies,

[7] Differently from ASI but more precisely, ESA does not include basic technology research into scientific programs, but into technology ones.

robotics and advanced sensors. The development of telecommunication allows to develop many and very relevant applications (multimedial communication – distance learning – distance working, etc.).

Similarly, earth sciences studies cannot be done without earth observation instruments; these have a series of applications whose importance is absolutely strategic and of great public relevance, like monitoring territory for military but also civil protection purpose.

Because of their importance, ASI has specific programmes for telecommunication and earth science and funds for R&D in these two fields are, as it possible to see from Table 2, particularly large.

In addition to these strategic sectors, spillovers of space technologies can be of a strictly industrial and commercial kind as well: launcher industry, for example, is strategic not only on a commercial but also occupational side.

We have seen the strict nexus between science and technology. ASI has however explicitly technological programmes, to which it dedicates 3.5% of its budget (a lower quote to that is generally considered optimal and it is in fact practised by ESA, that is 7-8%): in this case, there is not a knowledge goal, like in scientific programmes, and we are not talking anymore of basic technology research, but goals are really more specific and limited. Development of these specific technologies is directed both to properly space activities (radar technologies for the survey of space drifts – technologies for the measurement of atmospheric gases – technologies for sensorized spacesuits, etc.) and commercial applications to be utilized by small and medium enterprises (board computer – control instruments – optoelectronic instruments, etc.).

After having briefly analysed the contents, it seems interesting to see what is the funding practice of ASI programmes. Let us consider the case of scientific programmes: ASI advertises a competition that reports some ambits of research of interest and asks participants to present a research project in these ambits (or even in other ambits, but a project presented in a non reported ambit must be justified); then projects are evaluated and the best judged ones are financed. Basic selection criteria are verifiableness and timeliness (3 years) of results. Thus ASI has solved in this way a typical problem of public financing of research: which projects to finance and with which firms (the most established ones or is it preferable to diffuse research rewarding emerging firms)? (Gambardella, 1997); ASI, at least in theory, identifies “objective” criteria: it identifies itself fields of research and, in order to assign funds, only quality of proposal matters, not who proposes.

Obviously both universities and firms are receivers of such funds. In practice, it hardly ever happens that a firm applies for a funding in a scientific programme and the participation of a university or other research centres in a technological program is little less rare.

It has to be underlined that, in order to allocate its funds to firms, ASI takes into consideration also economic returns for the proponent firm, in view of a possible self-financing of the firm for the necessary development activities of the project. The results of a study conducted by the University of Rome – Tor Vergata underlines that the funding given by ASI to private enterprises generally do not generate a self-financing development, but these firms continue to rely on the continuous provision of funds. The causes may be found in the weakness of the space sector in Italy, rather than in ASI. The number of firms operating in this sector is in fact quite limited: the Italian market is characterized by the presence of a few big firms and several small firms. Therefore there is not a large competition in funds assignment for large projects. This may generate a dominant position for these large firms, that may subtract themselves to a real control by ASI. This may be interpreted as a signal of the great contractual power of such firms, that do not fear to loose further funds and therefore do not produce a sufficient effort to self-finance the development of those project; alternatively or jointly this result may be interpreted as a lack of rigorous evaluation of social and economic benefits of funding: indeed, if funding does not generate a self-enforcing capability inside the firms, the social benefit cannot be considered as positive. Many authors and ASI personnel itself underline the extreme difficulty to make a rigorous both ex-ante and ex-post evaluation of the funding. Anyway, as we will see in the last paragraph, evaluation is possible and indispensable.

The other criteria of preference to assign the research are particularly interesting:

a) programmes that impose synergies with research institution are given preference;

b) projects that have significant technological spillovers are given preference.

The point a) demonstrates that ASI appreciates synergies between innovative actors, following therefore the most recent guidelines of policy innovation. It must be underlined, however, that ASI rewards a foreseen interaction, but it does not carries it out; university and industry are both ASI points of reference, but it does not acts as an intermediary between them. For instance, the spirit of NASA, and of course the means it disposes, are different, as it actively operates in that sense, creating true innovative networks. NASA has a Commercial Technology Network (NCTN) that is a mechanism for enabling technology transfer and commercialisation. This network consists of a series of NASA-affiliated organizations across the United States that provide expertise and services to U.S. enterprises, facilitating the transfer, development and commercialisation of NASA-sponsored technology. This network provide a rapid access to the federal R&D base. Its core includes the National Technology Transfer Center and six Regional Technology Transfer Centers.

The federal R&D base involve more than 700 laboratories and centres nationwide; the centres sponsored by NASA then cooperate with other agencies. It is therefore remarkable the extension of this network, for number of agents involved and territorial diffusion.

Even though the network of the American system cannot be compared to the Italian one, it has to be remarked that the Italian space sector suffers much less than other sectors from the lack of interactions; this is in fact a field where interaction between university and industry is necessarily strong, apart from every external stimulus, because of its need to move on a very advanced technology frontier.

National Space Plan then illustrates the need to favour networks between firms, and indeed research activity in great projects is often characterized by collaborations between firms.

From the point b) it is possible to infer that, as we have already said, among the fundamental reasons for public funding of space activities, there is the consideration of spillovers such technologies may have. The notice of competition refers to spillovers *inside* the space sector, but also to activities that give a national "technological advantage".

Therefore the attention towards technological and knowledge spillovers is certainly present in funding choices of ASI, rewarding projects that seem to favour them, but a public agency can act in a more direct way, actively operating to favour the transfer of technologies from space sector to others, possibly with the interaction with research centres, scientific parks, etc.

The activity of ASI in this sense is still quite limited, probably because the cost-benefit calculation was not favourable to wide operations in that direction.

The attitude of ESA is instead different: it promoted a wide and articulated technology transfer programme (TTP), particularly directed to SME. What is particularly important to underline in this programme is the informative activity done by ESA: it is possible that especially small firms do not know all existing technological opportunities; in this case government, through the space agency, fills an informative gap, by means of the publication of a catalogue of the space technologies that may be utilized in other sectors. Obviously, this is only the pre-condition for technology transfer actions. Public competition is, also in this case, the chosen practice; therefore the firms that present an innovative project are put in contact with the firms already working for ESA and are then financed; for its part, ESA obtains an economic return, by means of payment of royalties, in the cases it has the intellectual property of the transferred innovation. The explicit ESA networking policy is mainly directed to overcome informative barriers but, even on the side of financial facilitation, it must be said that the chance to adopt already existing technologies implies for the firm a reduction of the production and product development costs.

We said that it would have been interesting to analyse the activities of a space agency in the light of Ergas taxonomy, if they are more oriented to great innovations or to diffusion; we also said that this largely depends on the orientation of the country as a whole. Indeed, it is quite difficult to collocate Italy into the Ergas taxonomy: it has a too weak high-tech sector and a low degree of technology policy concentration to be considered a mission-oriented country; its industrial structure based on medium and small enterprises could allow to classify it as a diffusion-oriented country, but, if compared with the more efficient countries belonging to this taxonomy, like Germany and Japan, Italy has a weaker education systems, lacks of efficient technology transfer institutions and the degree of collaboration between different institutions, like universities and firms, is still quite low (Malerba, 2000). The problems of scarce self-financing of funded firms on one side and the relative scarcity of the technology transfer activities on the other side may be seen as a sign of this twofold weakness.

On the side of diffusion-oriented activities, we have anyway to say that there are a lot of space agencies actions directed towards the development of the firms operating in the space sector. First of all we have to mention all the actions directed to increase the demand, that is, as we have seen, public for a large quote: in this direction, ASI promoted relationships with public firms or institutions (Italian Railways, Superior Institute of Health), with other structures of Public Administration that utilize public technologies (satellite technologies for earth observation), with research centres or even non-national institutions (UNO agencies, for instance).

ASI promoted spin-offs activities too, therefore creation of new firms, in the framework of the European Commission actions directed to that purpose; it financed innovative firms, also favouring their location in less developed areas of the country; it favoured the location in such areas of research centres and operations centres too, in order to generate beneficial territorial effects, expressly involving local universities, whose importance for territorial spillovers is now a widely accepted concept in economic literature (Jaffe, 1989). (In fact, there is the space centre in Matera, and Universities of Basilicata, Bari and Lecce are involved in ASI activities; there is the stratospheric balloon base in Trapani Milo and there is the involvement of the University of Palermo, etc.)

We have talked about the importance ASI attaches to joint research activities and to collaboration between institutions; it must be underlined, on this subject, that in several international activities ASI tried to develop wide international collaborations too (USA, Canada, Russia, Japan, Argentina, India, Brazil, Egypt). Participation to International Space Station is particularly important.

We have seen that ASI implements several policies directed towards different objectives. A lot of capabilities are needed to these different purposes in terms of human capital, technical and financial resources. A lot of tangibles and intangible assets investment are needed to sustain such an agency. Therefore it becomes a core of competencies and often tacit knowledge that are certainly a richness for the country as a whole. But we have seen that the Italian high-tech sector suffers of great weaknesses: there is therefore the risk that such competencies are underutilized and that these structural limits reduce the returns to such investments in tangible and intangible assets. Talking more in a metaphoric than in a material way, structural and dimension limits of the national system do not allow human capital and other intangible assets to keep the increasing returns that the students of the theory of growth ascribe to them. But returns are less than decreasing: tangible and intangible investments are costly; therefore, if they are underutilized or not utilized at all, the return becomes negative until a disinvestment happens, that is until the structure maintains its dimension and characteristics.

5. A summary about policies and the problem of evaluation of technology policy

From this brief examination of Italian Space Agency activities and, partially, of European Space Agency and NASA, we could notice that the activities of a space agency represent a very interesting and almost exhaustive list of the modalities of public intervention in research and innovation.

ASI activities can be synthesized in this way:

a) planning and funding basic research;
b) planning and funding technology research, basic and applied, taking into particular consideration technology and knowledge spillovers on the whole innovative and productive national system;
c) creating technological infrastructures;
d) promoting technology transfer (through funds and actions directed to fill information gaps);

e) stimulating cooperation between innovative agents, particularly between research institutions and industry and between firms;

f) carrying out localization policies of research and industrial activities in less developed areas.

Such activities represent a certainly significant picture of the possible ways of public intervention, both referring to a traditional view (which particularly underlines the importance of funding research, creating infrastructures and strengthening public demand), both referring to more modern conceptual frameworks, like national innovation system and knowledge economy, which underline the importance of technology and, more generally, of knowledge circulation, through the increase of collaboration between innovative agents, both on a national and a local level.

Anyway a consideration is needed: making a classification of the policies implemented by a public agency is an important but, in a certain sense, poor result: making a conceptual framework of the policies is interesting only if this operation is useful to make an evaluation of such policies.

Evaluation is even more important if we take into consideration the problem we have pointed out of the possible transformation of intangible assets into liabilities, which happens if capacities are underutilized: evaluation is necessary to understand if this happens.

The problem of evaluation of public policies and technology policies in particular is a main one and it presents a lot of difficulties. As we have seen, some problems related to the financing of firms may derive from difficulties in evaluating the results of technology policy. However, evaluation cannot be considered a black box. Several methods have been developed to evaluate technology policy (see Georghiou – Roessner, 2000, for an exhaustive review). For example Ergas (1987) states that a cost-benefit analysis for mission-oriented programmes is very difficult but he does not give up to indicate three factors that may be considered critical in differentiating success from failure:

a) agencies should have technical expertise, financial resources, operating autonomy sufficient to ensure that implemented programmes succeed;

b) relations with outside suppliers should allow to provide appropriate incentives and penalties and allow for experimentation with alternative design approaches;

c) agencies should be prevented from expanding their mission indefinitely.

Analysing in detail the three points would require a deeper inquiry than the one we have conducted. But something emerged regarding the point b): at least regarding the industry side, these conditions are difficultly assured by the limited dimension of the Italian aerospace markets. More generally, it is possible to say that the activity of Italian Space Agency is surely conditioned by the mentioned structural weaknesses of the Italian system, particularly in research and high-tech sector: competition in great projects is limited, because of the limited number of big firms in this sector and, as we have seen, such firms often are not able to become self-financing after they have received initial funds from ASI. It must be said that ASI is able to exploit technological situation of excellency and has surely contributed to develop a large system of collaboration between firms and between firms and universities. Anyway ASI personnel itself underlines that much more, under this respect, may be done.

A large part of space activities are pure science researches: a great effort in evaluating scientific research, through citation index or analogous tools, has been recently done. The study by Abramo (1998) is an interesting application to the Italian situation and particularly to a research institution, the national Research Council (CNR: Consiglio Nazionale delle Ricerche).

ASI has a “scientific observatory” that conducts a less rigorous anyway interesting survey of the results of funds granted for science programmes, based on postal interviews of the financed institutions. 82% of the institutions whose project were financed in 1997 declared to have reached the established goals and 63% of them developed a new technology. A survey of publications is also conducted: the number and share of publications on international journals varies considerably according to the field, from a share of nearly 20% for sciences of engineering (20% of total publications in this field are on international journals) to nearly 70% for life sciences.[8]

As we have many times stated, a powerful justification for public intervention in space sector is the presence of abundant research and technological spillovers to other sectors. The evaluation of such spillovers is another very difficult issue. This topic as well is not a black box: we quoted the study by Marengo and Sterlacchini (1990) that analyses the intersectoral technology flows; this theme has a well-known predecessor in the study by Scherer (1984): by examining patent data, he estimates the fraction of inventions originating in each industry that would be used by each industry. For the subject considered in this paper, it is interesting to cite the study by Jaffe (1998), because it is specifically dedicated to the evaluation of spillovers derived from the policy mission implemented by the American Advanced Technology Program. In this study Jaffe makes a distinction between knowledge, technological and network spillovers. The lack of data or their scarce significance (e.g. patents in Italy are not very significant because firms rarely patent their innovations) is often, in many countries or sectors, a great obstacle to the calculations of these flows; it is then necessary to overcome this difficulty, as an interesting study by Kaiser (2002) suggests, by taking into considerations the factors, more easily calculable, that determine knowledge flows, obtaining therefore an approximation of them. But the theory regarding this topic is not sufficiently developed: there is still the need to improve our understanding of knowledge diffusion and creation in network, as outlined in the first report of this research unit. Of course, conceptual framework cited above should be the base to improve our knowledge regarding these phenomena.

But there is not only a technical, conceptual problem: evaluation is also a problem of culture and mentality, of habit, willingness and means. This is largely a political problem: there is a sort of natural tendency of the “bureaucracy” to shirk evaluation, particularly economic evaluation, that is to consider the results on an economic point of view. But the request of efficiency and responsibility of public institutions is

[8] The complete results of the survey for 1997 and 1998 (but the second one does not include the publications survey) are on the following web page:
http://ars.asi.it/˜webars/osservatorio/relazione_fondi97-98.html

increasing and, even though they often have social or “mission” goals, the economic crisis of welfare state urges to a more rigorous evaluation of the efficiency of the use of public money.

The United States have, paradoxically perhaps because of their historical scepticism towards the action of the government, a more ancient tradition in this sense; a significant conceptual effort in the field of technology policy has been produced, but this effort has not remained confined in the academies: prestigious academicians have been often called to give a conceptual but also applicable framework to evaluate specific policies and the economic focus is prominent (see Jaffe, 1998 and 2002). Anyway, in recent years the awareness of the need of a rigorous evaluation of public policies has greatly increased also throughout the EU countries, but some grey zones still remain.

Regarding the Italian situation, in the field of technology policy it must be mentioned that a law in 1998 founded a committee for the evaluation of research (CIVR: Comitato di Indirizzo per la Valutazione della Ricerca), belonging to the Ministry of Education, University and Research, the same which ASI belongs to. This committee established some indicators and principles according to which the activities of the agencies and organizations dedicated to research should be evaluated. It is perhaps significant that the Italian Space Agency did not submit to CIVR sufficient documentation to let an evaluation in 2001. Indeed ASI personnel itself feels lack of rigorous evaluation as one of the main shortcomings of the agency. The new chairmanship of the agency seems aware of the need of a more rigorous and systematic evaluation.

In the end, looking for policy implications for EU, it is evident that the European intellectual and practical effort must be focused on two issues: increasing the capability to deeply understand the functioning of a network dedicated to the creation and diffusion of innovation and increasing the ability to evaluate the results of public policy, also in quite complicated fields like technological policy. The joint intellectual and practical effort may conduct to increase the European capacity to innovate and diffuse innovation and, through a better comprehension of the process of creation and circulation of knowledge, to better allocate public funds and to establish more precise and concrete policy goals and practices.

6. What about intangible assets?

We said that the arguments developed in this paper need a further intellectual effort. An important part of this effort is certainly represented by the deepening of the intangible assets theory. In fact the points underlined above may be seen in the light of this theory: evaluating public policy means largely evaluating intangibles. We have seen that implementing spillovers and the capacity of innovative agents to interact are the main goals of technology policy; but spillovers and this capability are two main intangible assets of the firms and of the economic system as a whole, as they are a non-material source of innovation capacity and therefore productivity.

These two issues may be conceptualised in the light of market failures (spillovers) or “institutional failures”, as there may be some non-market frictions to the interaction of different institutions, that have different goals and modalities of operating (see Bianchi, Iorio, Malagoli, Labory, 2002, for the problem of interactions between universities and industries).

Other cases cannot easily be completely conceptualised in these two kinds of failure and therefore they require more sophisticated analyses and solutions. For example, particularly in fields where large and differentiated competences are required, there is the risk not only that such competencies do not match together (that is the case of "institutional failure" seen before) but also that they would be "dispersed". We are obviously referring to fields of specific public interest, where there are not enough private incentives to avoid this risk. Therefore, this is *also* a case of market failure, but the solution cannot be the traditional one, increasing private incentives or to subsidising private agents: for such a problem monetary incentives would not be effective. In this case, the role of public authorities is to "keep resources together", where we are referring particularly to intangible resources. A public agency could be the more appropriate instrument.

A public agency favours the accumulation and coordination of competencies. But this implies a risk: a public organism has the tendency to grow or at least to keep itself at the same dimension, even beyond the real needs or the concrete possibilities to operate. The other typical risk of a bureaucratic organism is to develop routines that may become rigidities. When this "concentration of intangible assets", which a public agency represents, becomes too great as regard the needs or less dynamic then the environment where it should operate, such intangible assets present a social cost, and they may turn into liabilities. This issue may be the new frontier of the intangible assets theory, the dark side of the moon that needs to be lighted.

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