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Competition between basic and applied research in the organizational behaviour of public research labs

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Abstract. The purpose of this paper is to investigate the competition between basic and applied research within public research organizations. International publications are considered here a proxy of basic research, whereas self-financing deriving from technology transfer activities is an indicator of applied research. Results suggest, within one of the largest European research organizations an increasing competition between basic and applied research, both in human and natural sciences, due to shrinking of public research lab budgets. In particular, institutes and scientists pay more attention to applied research activities, which are capable of attracting market funds for economic survival of public research labs but this organizational behaviour reduces basic research activity in the long run. Managerial and organizational behaviour of public research organizations are also discussed.

Keywords. Applied research, Basic research, Public research organization, Public lab, Science policy, Organizational behaviour, Public management.
JEL. B50, B59, I23, L20, L29, O33.

1. Introduction

The research sector (Senker, 2001) is undoubtedly one of the most controversial topics of political debate in many countries. The discussion concerns both public financing and organization. In fact, each country organises and manages public research institutions in order to increase the production of scientific research and technology transfer, more and more necessary to firms' competitiveness and economic growth (Romer, 1990). Generally speaking, scientific research is divided into basic and applied research. The first attempts at systematically defining these terms occurred in Britain in the 1930s, more precisely among those scientists interested in the social aspects of science. Frascati's manual (OECD, 1968) defines *Basic research* as experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts without any specific application or purpose. On the other hand, *Oriented-basic research* is carried out with the expectation of producing a broad base of knowledge likely to form the background to the solution of recognized or expected current or future problems or possibilities (Calvert, 2004).

As Needham (1959) says, there is no sharp distinction between "pure" and "applied" science: "There is really only science with long term promise of application and science with short term promise of application. True knowledge emerges from both kinds of science".

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The problems we wish to tackle are the following: are there trade-offs between basic and applied research? What is the behaviour of research institutes in the production of scientific research?

To answer these important economic questions, the purpose of the paper is to investigate the relationship between basic and applied research, and the scientific behaviour of public research institutes in the production of scientific research. In particular, the paper analyses the presence of rivalries between basic and applied research within the institutes of the most important Italian public research institutions, the Italian National Research Council. These results may provide useful information to policy makers in order to assign specific objectives and improve the efficiency of these public research labs. The next paragraph describes the theoretical framework, while the third section deals with the methodology of the research. The fourth paragraph shows the results. The discussion and concluding remarks describe the causes of the phenomenon and the effects of these issues on the behaviour of public research bodies.

2. Theoretical background

Nowadays when more and more political pressure is put on public research in order to boost its contribution to the common good (applied research) and to achieve more targeted effects by doing basic research in the fields of economy and society, many ask themselves how these objectives can be achieved without negative consequences on basic research[1]. In other words, several *policy makers* have raised the problem of how to encourage researchers working in public institutions to collaborate with private enterprises or to transform the basic research into applied research. This new approach of the researchers may generate competition between basic and applied research carried out within the institutes, even if the literature on economics of science and innovation argues that technical applications could be positively associated with scientific productivity (Stephan *et al.*, 2002, Van Looy *et al.*, 2004) or with the number of quotes (Agrawal & Handerson, 2002; Diamond, 1986a). Van Looy *et al.* (2005) demonstrate that papers issued by departments focused on applied research activities are more science-oriented than those created by departments working on basic research. Among the most recent contributions, a number of studies analyses the relationship between scientists and industrial partners, who patent the results of their discoveries (David, 2000; Nelson, 2001; Mowery *et al.*, 2002). However, the analysis of the rivalry between different types of scientific research is connected to issues concerning the public nature of knowledge (Arrow, 1962) and the appropriate reward system to support basic research (Dasgupta & David, 1994; Gallini & Scothmer, 2001). Rivalry has been increasing also because it is the scientists' duty to manage the good called "knowledge", which can be used for several different purposes. In this sense, scientists are considered multi-objective agents, carrying out a wide set of activities, ranging from basic research to teaching, consulting, and so on (Levin & Stephan, 1991; Lach & Shankerman, 2003). Stephan *et al.* (2002) claim that there are very good reasons to believe that applied and basic research can be reciprocally supported. Carraro *et al.* (2001) and Fransman (2001) assert that some scientific discoveries derive from intense

[1] For other studies about processes of scientific research and technology in economic systems, as well as managerial and organizational behaviour of public research labs, cf., Calabrese *et al.*, 2005; Cariola & Coccia, 2004; Cavallo *et al.*, 2014, 2014a, 2015; Coccia, 2001, 2003, 2004, 2005, 2005a, 2005b, 2005c, 2006, 2006a, 2007, 2008, 2008a, 2008b, 2009, 2009a, 2010, 2010a, 2010b, 2010c, 2010d, 2010e, 2011, 2012, 2012a, 2012b, 2012c, 2012d, 2013, 2013a, 2014, 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2015, 2015a, 2015b, 2015c, 2015d, 2016, 2016a, 2016b, 2016c, 2017, 2017a, 2017b, 2017c, 2017d, 2018, Coccia & Bozeman, 2016; Coccia & Finardi, 2012, 2013; Coccia & Wang, 2015, 2016; Coccia & Cadario, 2014; Coccia *et al.,* 2015, 2012, Coccia & Rolfo, 2000, 2002, 2009, 2012, 2007, 2010, 2010, 2013; Coccia & Wang, 2015, 2016; Rolfo & Coccia, 2005.

interactions between basic and applied research (science and technology) and it would be impossible to achieve them otherwise[2]. Calderini & Franzoni (2004) study rivalry issues (over a three-year period) on a panel of 1,323 Italian researchers operating in the field of engineering and materials science, adopting the number of the researchers' patents as the hypothesis for applied research. Using a negative binomial function, they show that the patenting activity (applied research) carried out during the same period or in earlier periods generates a positive impact on the number and quality of publications (basic research), both in the same period and in later periods. Studying the researchers within the Katholieke Universiteit Leuven, Van Looy *et al.* (2005) reach similar results. To sum up, the economic analysis of the rivalry between basic and applied research has led to a series of non-univocal results, with remarkable differences among various scientific fields. Specifically, the problem seems to be related both to the indicators used (above all, patents) and to the time period selected for the analysis, as well as to the focus of the investigation, which is represented in the vast majority of cases by individual researchers (Diamond, 1986). Although some economists are aware of the rivalry existing between basic and applied research, there have been very few empirical tests and analyses concerning the causes and effects of the phenomenon. This weakness of the economic literature is a problem both from the managerial point of view and at the research policy level. Therefore, this paper investigates the rivalry between basic and applied research within the biggest Italian public research body, analysing the main determinants among different scientific fields and effects on economic systems in the long run. The results may provide information to policy makers in order to increase the efficiency of these structures and of the overall national system of innovation (Lundvall, 1992). The methodology is described in the following section.

3. Materials and methods

The research uses data regarding 2000-2003 provided by the Italian National Research Council (CNR). CNR is a public research body (similar to the French *Centre National de la Recerche Scientifique*, to the German *Max-Planck Gesellschaft* and to the Spanish *Consejo Superior de Investigaciones Científicas*) which promotes, coordinates, and regulates Italian scientific research with the aim of advancing the Country's scientific and technological progress. Its 108 research institutes are public funded to produce scientific research according to general guidelines set by the Italian Government and the European Commission.

This paper investigates the relationship between applied and basic research, since this can affect the country's economic growth in the long run. First of all, the definition of scientific rivalry is given:

Scientific rivalry is the increase of applied research and simultaneously the reduction of basic research with negative effects on economic growth in the long run.

In this paper, the number of international publications and the total number of publications by researchers of the institutes are considered a proxy of basic research, while the institutes' technological transfer activities are considered a proxy of applied research. In particular, the paper uses the revenues deriving from technology transfer activities in the broad sense (Coccia & Rolfo, 2002),

[2] For other studies of sources of science, technology and research labs, cf., Calabrese *et al.,* 2005; Cariola & Coccia, 2004; Cavallo *et al.,* 2014, 2014a, 2015; Coccia, 2001, 2003, 2004, 2005, 2005a, 2005b, 2005c, 2006, 2006a, 2007, 2008, 2008a, 2008b, 2009, 2009a, 2010, 2010a, 2010b, 2010c, 2010d, 2010e, 2011, 2012, 2012a, 2012b, 2012c, 2012d, 2013, 2013a, 2014, 2014a, 2014b, 2014c, 2014d, 2014e, 2014f, 2014g, 2015, 2015a, 2015b, 2015c, 2015d, 2016, 2016a, 2016b, 2016c, 2017, 2017a, 2017b, 2017c, 2017d, 2018, Coccia & Bozeman, 2016; Coccia & Finardi, 2012, 2013; Coccia & Wang, 2015, 2016; Coccia & Cadario, 2014; Coccia *et al.,* 2015, 2012, Coccia & Rolfo, 2000, 2002, 2009, 2012, 2007, 2010, 2010, 2013; Coccia & Wang, 2015, 2016; Rolfo & Coccia, 2005.

represented by: a) analysis and technical tests (chemical and physical); b) technological services (homologation, calibration, nuclear magnetic resonance, etc.); c) quality services (accreditation, certification, quality control, etc.); d) environmental services (water monitoring, pollutant emission control, etc.); e) information technology services (data elaboration, supply of databases and data, etc.); f) health services; g) research contracts with firms and institutions.

Patents are not used as an indicator of applied research because of low number of patents within the CNR. Consequently, technological transfer activities are preferred as proxy of applied research activities.

Therefore:

- The number of international publications and/or the total number of publications (x_i) are indicators of public laboratories' basic research;
- The financial income deriving from technological transfer activities (y_i) is an indicator of the institutes' applied research.

The above variables are identified in relation to each of the five scientific fields (basic, life, earth and environment, social and human, engineering and information sciences), in which the 108 CNR institutes were operating during the 2000-2003 period. The analysis of the rivalry is carried out using two methodologies: the non-parametric rank statistics and the concentration indices, to countercheck the previous results and to investigate the behaviour of public research institutes in depth.

In order to avoid the size of the institutes affecting these variables, the first step is the computation of the value pro-capita for each individual researcher in each institute. For researchers we intend only the payroll employees with the status of civil servants, associate researchers (belonging to universities), PhD candidates, and post-doc fellows are not included.

$$\bar{x}_i = \text{average value procapita of basic research i-th institute} = \frac{\text{variable (no. of publications) i-th institute}}{\text{researchers of the i-th laboratory}}$$

$$\bar{y}_i = \textit{average} \text{ value procapita of applied research i-th institute} =$$
$$= \frac{\text{variable (revenue from technology tranfer activities) i-th institute}}{\text{researchers of the i-th laboratory}}$$

In order to apply the first method, the research institutes are arranged in descending order (from the highest to the lowest value), according to the two above indicators of basic and applied research $(\bar{x}_i, \bar{y}_i)$, to create ordinal variables. The degree of relation of these two ordinal variables is measured by a non-parametric rank statistic: the rank correlation coefficients. This index is a measure of the strength of the association between two variables. We use these coefficients, since the scientific research and technology transfer carried out by the institutes are not easy to measure, for instance an institute can have a lower number of publications but of higher quality than another one. For this reason, we prefer to construct lists and not to indicate the accurate values, which are proportional variations of the intensity of the variables. Therefore, the variables $(\bar{x}_i, \bar{y}_i)$ are substituted by the values (r_i and s_i) that express the ranks of the institutes. Then, s'_i, being the ranking number of $\bar{y}_i$ in the descending list, is calculated so that:

$$s'_i = N + 1 - s_i$$

where N is the total number of cases. The main indices based on two ordinal variables are those of Spearman and Gini:

$$\text{Spearman rank correlation coefficient} = \rho = \frac{6\sum_{i=1}^{N}(r_i - s_i)^2}{N(N^2-1)}$$

Gini's rank correlation coefficient has the same aim as Spearman's index, and it is used in this paper to check the previous results. The formula is given by:

$$G = \frac{\sum_{i=1}^{N}\left|r_i - s_i^{'}\right| - \sum_{i=1}^{N}\left|r_i - s_i\right|}{\left[\frac{N^2}{2}\right]}$$

The value of these indices is +1 when there is a perfect (positive) rank correlation, i.e. the highest relationship between the variables. The value is −1 when there is the lowest relationship between the variables.

To sum up, the following hypotheses are stated:

- if ρ or G are *negative* ⇒ there is *rivalry* between basic and applied research within public research institutions.
- if ρ or G are *positive* ⇒ there is *NO rivalry* between basic and applied research within public research institutions.

The second method used to investigate the behaviour of the institutes in the production of basic and applied research is the concentration index. In this case, the analysis is carried out considering absolute values rather than average values, which are used in the previous analysis. Since scientific fields of research are similar to sectors, this method is an effective analysis tool of scientific labs' behaviour. In fact, it shows, for each scientific field, whether institutes focusing on basic research are the same institutes as those focusing on applied research. The economic literature provides several measures for the magnitude of inequalities. One specific indicator is Gini's coefficient, which measures the degree of concentration (inequality) of a variable in a distribution of elements (Girone and Salvemini, 1988):

$$R = index\ \ of\ \ concentration = \frac{\sum_{i=1}^{N-1}(p_i - q_i)}{\sum_{i=1}^{N-1} p_i}$$

Where x_i = total number of elements of *i* case (e.g. number of Publications of *i-th* laboratory), p_i is i/N (N is the total number of elements), A_i = cumulative values of x_i, while q_i is A_i / A_N. Gini's coefficient ranges between 0, when there is no concentration (perfect equality), and 1 when there is total concentration (perfect inequality).

Moreover, this method considers 10% and 25% of the best-performing research institutes working on applied research to measure the cumulative percentage of their basic research. This measure is carried out per year and scientific field. Excel and SPSS® statistic packages are applied.

4. Results

The structure of the Italian CNR (since 2001), after a reorganisation policy, is based on 108 institutes, which have 191 decentralised units. They operate in five scientific fields, which are the basis of 11 scientific departments: 1) Basic sciences, with research bodies operating in the field of mathematics, physics, and chemistry; 2) Life sciences, with institutes working in the field of medicine, biology, agriculture, and molecular biology; 3) Earth and environmental sciences (geology, environment, and habitat); 4) Social sciences and humanities, including institutions operating in the field of history, philosophy, and philology; law and political science; economics, sociology, and statistics; artistic heritage; 5) Technological sciences, engineering, and information technology, made up of structures operating in the field of engineering, architecture, technology, and information technology.

The results are presented for each of the five fields, due to the fact that each field has distinguishing structural features and scientific activities (tables 1 and 2).

- *Basic Sciences*

Basic sciences were made up of 28 research institutes of medium-large size, with an average number of researchers of 38.64 units and an average public funding of over 593,000 Euro (2000-2003 period). Year by year, the average number of employees increased, going from 28.61 in 2000 to the average value of 44.82 in 2003. Average funding decreased constantly through the years, going from over 615,000 Euro to around 560,000 Euro in 2003. This field has undergone prominent changes, from an initial state when Gini's and Spearman's indices showed absence of rivalry between basic and applied research to the scenario of more recent years, in which there is rivalry between basic and applied research. Spearman's index shows rivalry both in 2002 and in 2003, while Gini's index shows it in 2003 only.

- *Life Sciences*

With its 33 institutes, this was the field that included the highest number of institutes within CNR. They were usually of medium-large size, with an average number of employees of 34.99 units per institute during the 2000-2003 and an average amount of public funds of around 511,000 Euro. The mergers of different institutes, following the reorganisation started in 2001 and still ongoing as of today, have led to an increase in the average number of researchers per institute from 25.70 in 2000 to 42.09 in 2003. Similarly, to basic sciences, public funds dropped during the four-year period reaching less than 491,000 Euro in the last year. Both Spearman's and Gini's indices show that there is rivalry between basic and applied research with ups and downs every other year. Rivalry was lower in certain years (2000 and 2002) and higher in others (2001 and 2003).

- *Earth and Environmental Sciences*

This was the field of CNR with the smallest number of research institutes, numbering only 10; they were, however, of fairly large size, since the average number of researchers (in the 2000-2003 period) was considerably higher than in other fields, 45.02 researchers each, and the average financial resources were above 780,000 Euro. The institutes included in this field grew through the years, going from 36.20 units in 2000 to 55.90 units in 2003. As far as public funding was concerned, similarly to the other fields, there was a constant decrease as the years went by.

Both Gini's and Spearman's indices show an initial lack of rivalry between basic and applied research, that turned into a competitive situation in the last years of the period, proven more evidently by Spearman's index rather than by Gini's.

- *Social and Human Sciences*

This field included 19 research institutes of smaller size in comparison to the other fields: On average, during the four-year period, they had 14.81 units and the lowest financial resources among all the CNR institutes, less than 249,000 Euro. Through the years, the changes undergone by these institutes were the same as those taking place in other fields, with an increase in the average number of researchers (due to mergers) and the reduction of funding (due to the reduction in public financing for research activities enacted by Italian governments in the last decade). This is the only field that showed an initial situation of rivalry between basic and applied research, measured by the two indices, while in the following years there was a lack of rivalry. In fact, contrary to the other fields, here revenues deriving from technological transfer activities dropped off, while the number of international publications rose.

- *Technological, Engineering, and Information Technology Sciences*

This field includes 18 research institutes, which are of medium size in comparison to the other fields. The average number of researchers was 28.65

during the 2000-2003 period, while average public funding in the same period was over 551,000 Euro. As for the other fields, the average number of researchers rose constantly, while public financial resources decreased. Gini's and Spearman's indices show a constant rivalry between basic and applied research, even though the values decreased slightly through the years. These results are summarised in tables 1 and 2, which display a general overview.

Table 1. *Rank correlation coefficient of research institutes producing basic research* and applied research***

	Arithmetic mean per researcher	
	G *Gini*	*ρ* *Spearman*
2000	0.017147	0.044385
2001	−0.125857	−0.126764
2002	0.024691	0.072690
2003	−0.035322	−0.027875

* = measured by number of International publications;
**=measured by revenue from technology transfer activities.

Table 2. *Rank correlation coefficient between basic research* and applied research**- per scientific field and year*

	Scientific field	*No. of institutes*	*Year*	*G* *Gini*	*ρ* *Spearman*
1	Basic sciences	28	2000	0.148	0.162
			2001	0.128	0.055
			2002	0.020	−0.008
			2003	−0.204	−0.284
2	Life sciences	33	2000	−0.184	−0.201
			2001	−0.492	−0.617
			2002	−0.121	−0.133
			2003	−0.298	−0.334
3	Earth and environmental sciences	10	2000	0.320	0.406
			2001	0.000	−0.055
			2002	−0.120	−0.127
			2003	−0.040	−0.006
4	Social sciences	19	2000	−0.122	−0.126
			2001	0.188	0.253
			2002	0.022	0.072
			2003	0.244	0.332
5	Engineering and Information and communication technologies sciences	18	2000	−0.235	−0.302
			2001	−0.148	−0.222
			2002	−0.037	−0.065
			2003	−0.123	−0.187

* = measured by number of international publications;
**=measured by revenue from technology transfer activities.

- *Behaviour of the institutes in the production of basic and applied research*

This analysis is carried out first on an aggregate level and then divided by fields and years. The analysis of all the 108 institutes of the National Research Council of Italy shows that there has been a trend of concentration growth among the institutes producing applied research. Gini's concentration index (R) increased from 62.58% in 2000 to 69.53% in 2003.

On the other hand, the concentration of basic research decreased in the same period, going from 48.83% to 45.87% (Table 3).

Table 3. *Concentration index of basic research and applied research within the 108 Italian public research institutes (period 2000–2003)*

Years	*Applied research*	*Basic research measured by International publications*	*Basic research measured by total publications*
2000	62.58	48.83	42.95
2001	70.92	48.86	39.98
2002	71.12	47.08	40.59
2003	69.53	45.87	37.49

The competition between basic and applied research is present when considering 10% of the institutes with the best applied research performance (which, as stated above, is measured by the revenues resulting from technological transfer activities). In 2000, 10% of the research units produced 47.05% of the total applied research during that year. The same institutes, during the same year, produced only 18.45% of basic research (measured by total publications). This analysis, repeated in the following years, shows a growth trend in relation to the production of applied research that is a staggering 58.45% of the total in 2003, counterbalanced by a constant decrease in the production of basic research, which during the last year is a mere 13.27% of the total (Table 4).

Table 4. *Cumulative (%) of applied and basic research produced by 10% of the best-performing research institutes in applied research (period 2000-2003)*

Year	*Applied research*	*Basic research measured by International publications*	*Basic research measured by total publications*
2000	47.05	17.94	18.45
2001	60.01	14.66	14.71
2002	59.39	14.38	15.05
2003	58.45	12.95	13.27

The overall situation described above is actually rather diversified throughout the different fields. As far as applied and basic research are concerned, basic sciences have a substantial reduction in concentration during the 2000-2003 period. The concentration reduction trend can be observed in social sciences (even though initially there was a higher concentration in these two activities when compared to the previous field) and in technological, engineering and information technology sciences. Life sciences and earth and environmental sciences share a similar behaviour in their concentration indices: there is an increase in concentration of applied research, while basic research has an initial reduction followed by either an increase or a rising and falling trend (table 5). The analysis is repeated considering 25% of the institutes with the best applied research performance (which, as stated above, is measured by the revenues resulting from technological transfer activities). After that, the same institutes are also considered in relation to basic research, in their respective fields and years. The results display a high rivalry between basic and applied research over time within the institutes of all scientific fields (see table 5), except social sciences.

Table 5. *Concentration among 108 Italian public research units- per typology and year*

Year		*Scientific field*	*Concentration* – *Index of concentration* – *Applied research*	*Index of concentration* – *Basic research (measure by International publications)*	*Cumulative (%) of applied and basic research produced by 25% of the best-performing research institutes in applied research* – *Applied research*	*Cumulative (%) …* – *Basic research (measured by International publications)*
2000	1	Basic sciences	60.70	38.48	68.27	34.75
2001			57.90	34.85	67.95	32.04
2002			59.31	32.66	68.34	31.24
2003			47.13	35.39	56.83	29.21
2000	2	Life sciences	60.23	34.48	64.03	21.89
2001			81.44	31.28	83.34	19.47
2002			79.62	32.06	82.56	26.37
2003			79.77	35.20	83.23	22.71
2000	3	Earth and Environment Sciences	50.05	38.00	63.80	36.09
2001			50.21	36.19	67.47	34.92
2002			49.05	44.92	63.02	29.51
2003			53.35	34.58	67.40	30.68
2000	4	Social sciences	74.52	51.49	82.97	20.90
2001			77.27	49.19	81.89	46.95
2002			63.28	41.00	72.33	31.03
2003			65.29	37.73	72.44	38.67
2000	5	Engineering and Information and communication technologies sciences	49.12	52.28	60.11	25.39
2001			51.13	50.71	63.56	28.79
2002			46.79	48.29	58.59	27.82
2003			47.75	46.37	59.53	23.39

5. Discussion and concluding observations

The economic literature (Calderini & Franzoni, 2004; Van Looy *et al.*, 2005) shows that the applied research measured by patents has a positive impact on publications (basic research), but if the revenues deriving from technology transfer are considered as an indicator of applied research, the situation changes. In fact, this research shows a general rivalry between basic and applied research, in the sense that the latter seems to turn to the disadvantage of the former and vice versa.

Which are the causes of this rivalry? Why is the rivalry present in Natural Sciences (basic, life, earth and environmental, engineering and information technology sciences; the abbreviation used is NES) and absent in Social and Human Sciences (abbreviation used is SHS)?

The results of this research are the basis of the following *proposition:* The reduction of public funds is the cause of an increasing rivalry between basic and applied research: the main effect of reducing public funds is an increasing in applied research measured by the revenues deriving from technology transfer activities and decreasing scientific publications (basic research).

The research policy reform of the Italian Government has been cutting public funds to public research institutes (figure 1A and 1B). Simultaneously increasing political influences to encourage collaboration between research labs and firms/other institutions have the effect of increasing self-financing deriving from technology transfer (applied research). In fact, Italian researchers working in research laboratories of NES, with a Hawthorne effect, would like to show a higher efficiency, therefore they have changed their approach towards the market, seen now as an important source to gather financial resources that are necessary to the economic survival of research institutes. Now, the NES's researchers focus their scientific activity towards applied research and consultancy to firms and public institutions, since their scientific field produces outputs of immediate industrial use

(Coccia & Rolfo, 2002). A shift towards applied research activities in NES has led to an increase in self-financing but also in the rivalry with basic research activities, measured by scientific publications, which have been decreasing. Most of the institutes operate as *quasi-business firms* (Etzkowitz, 2003) due to the fact that *working time* of researchers when choosing between basic and applied research is a normal good with a negative slope that brings about a trade-off between these two activities. Figure 1A shows a rivalry in Natural sciences – NES (basic, life, earth and environmental, engineering and information technology sciences). In the selected period (2000-2003), total revenues deriving from applied research rose considerably, while the production of basic research decreased slightly *(scientific rivalry gap),* even if within the NES there are basic, life, earth, environment, engineering, ICT sciences, which have different behaviours over time.

Why is this phenomenon absent in Social and Human Sciences (SHS)?

Since the SHS has limited relations with the market due to its particular researches in history, philosophy, philology, Latin literature, and so on, researchers can rarely find private patrons. Therefore, researchers focus their scientific activities on education, domestic and international publications and this behaviour has not affected the reduction in scientific productivity (Coccia & Rolfo, 2002, see Figure 1B).

Moreover, the increase of scientific productivity over time within SHS may be also due to the smaller size of this field in comparison to NES. In fact, the economic literature shows that smaller institutes are more efficient (Carayol & Matt, 2004; Coccia, 2005) and therefore more flexible to organisation and scenario changes.

The rivalry within the Italian CNR has his roots in the reorganisation and research policy of the Government, which has the aim of increasing the efficiency of the overall scientific organization by means of a concentration of the existing resources. The main result is the reduction of certain costs (personnel, rents, and so on), but in terms of output increase the effects seem very much ambiguous. In fact, cuts in public funds and the uncertainty of the research policy reform create some diseconomies of scale, due to the increased costs of co-ordination of decentralised units, with a negative influence on the productivity of publications (basic research).

The analysis carried out in this research on the relationship between basic and applied research is important, since it shows that the new Italian research policy has created hybrid research laboratories ("*with many characteristics of the business firm, except for the profit motive*"; Viale & Etzkowitz, 2004), which focus on consultancies and applied research rather than basic research. Public research laboratories are not business firms, they do not maximize the profit, but their scientific reputation. Moreover, they have a different institutional mission and produce scientific research which is a public good (Arrow, 1962); so, the Italian research policy that has been reducing basic research can has negative effects on competitiveness and the country's long-term economic growth (Hare & Wyatt, 1992; Callon & Foray, 1997). This also generates a low economic performance of the whole Italian system (e.g. low growth rate of GDP and so on, Coccia, 2005a). In fact, according to the modern theory of endogenous growth (Romer, 1990), the reduction of scientific research and therefore of innovation is not the best way to push the systems towards future patterns of economic growth.

Appendix

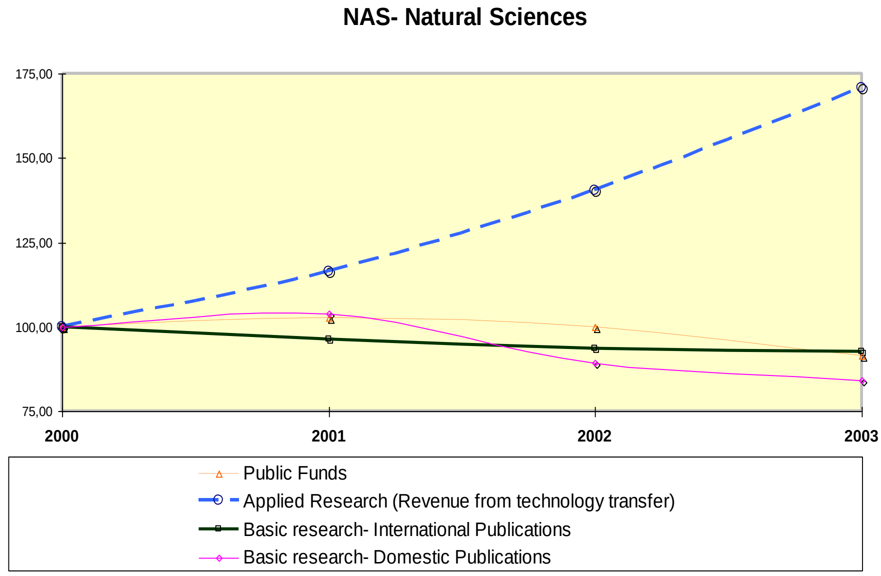

Figure 1A. *Dynamics of scientific research in NES over time (base 100=2000)*

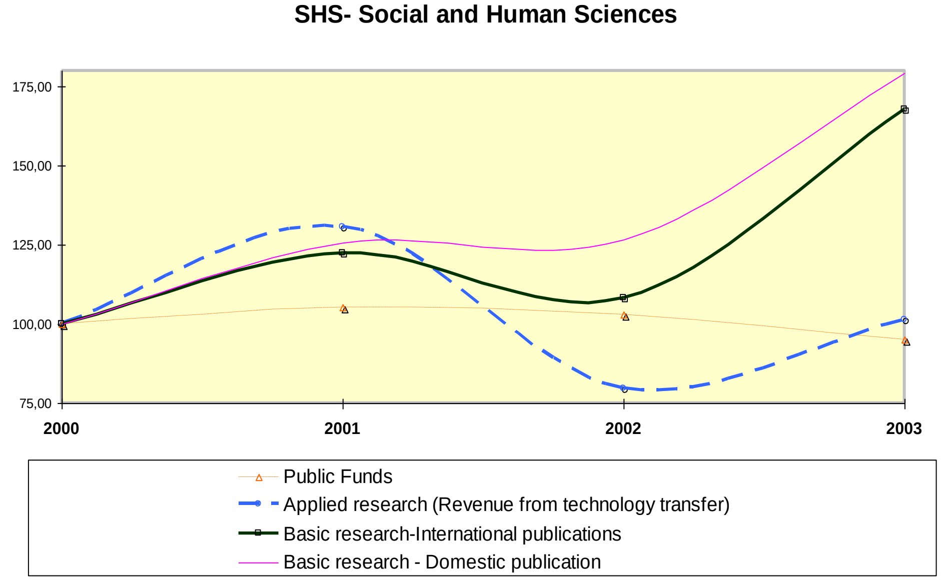

Figure 1B. *Dynamics of scientific research in SHS over time (base 100=2000)*

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