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Internal organizational demography of public research institutions

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ABSTRACT: The purpose of this paper is to analyse the public research organizations by a demographic approach. The research focuses on the biggest Italian public research body, considering personnel data of 2004. The results show the irregular spatial structure of the research personnel per macro regions as well as the average age of hiring and index of seniority over time, indicating older research personnel in North and Central Part of Italy than South Italy. This analysis displays the evolutionary change of the research personnel and provides vital information to policymakers in order to improve the future organizational behaviour of this main research institution.

KEYWORDS: Organizational studies, Public Research Institutes, Human Resources

JEL-CODES: I20, J11, J26

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1. INTRODUCTION

Research institutions play a central role in modern national system of innovation since they support current economic growth patterns (Aghion and Howitt, 1998). As these institutions are complex entities that have been adapting to environmental pressures generated by political change, turbulent markets, low public funding and so on, it is interesting to analyze their structure by a demographic perspective in order to support the evolutionary change over time. In general, human demography begins with the investigations of mortality rates in London by John Graunt. Now it is a distinct discipline that provides a vast amount of useful information about the dynamics of human populations for social scientist, policymakers and general public (Blangiardo, 1997; Livi Bacci, 1999; Caselli *et al.*, 2001).

As far as the organizations are concerned, there is a different situation. Several attempts were made in the 1950s and 1960s to develop a demography of organizations, however, there were poor results. As a matter of fact, knowledge about the demography of organizations in modern world has been slow to develop, although it can provide vital findings to understand their organizational behaviours in turbulent and dynamic scenarios. A main contribution to the demography of corporations and industries has been done by Carroll and Hannan (2000), whereas as far as the organizational behaviour of public institutions (such as the research ones) is concerned, the demographic studies have been not get well explored by economic analysts.

The purpose of this paper is to analyze, by a demographic approach, the research institutions, focusing on the Italian public research bodies. This analysis can provide vital results to support the evolutionary and strategic change (Gioia and Chittipeddi, 1991) of these main research organizations operating within the national system of innovation¹. Before analyzing this

¹ The national system of innovation (NSI) refers to the complex network of agents, policies, and institutions supporting the process of technical advance in an economy (Lundvall, 1992). The narrow definition of

topic, the theoretical framework and methodology of research are introduced.

2. DEMOGRAPHIC STUDIES OF ORGANIZATIONS

Carroll and Hannan (2000) claim that the demographic studies about the corporate populations are much more limited than human population. In fact, the use of publicly available data imposes severe limitations and as consequence, it is difficult to construct estimates of basic demographic facts. Demography in organizational settings involves the work force of organizations, especially its turnover and mobility (Bourdieu, 1988). For instance, the mobility within the organization typically focuses on the characteristics and effects of established internal labour markets (Doeringer and Priore, 1971). Recent works in this tradition address issues such as the sex segregation in jobs, fragmentation of work, and the opportunity structure within organizations (Carroll and Hannan, 2000; Palomba, 2001; Calcatelli *et al.*, 2003). A main topic of demographic research on organizations is called as *internal organizational demography*. Pfeffer (1983) defines demography as “the composition, in terms of basic attributes such as age, sex, educational level, length of service, race and so forth of the social unit under study ... the demography of any social entity is the composite aggregation of the characteristics of the individual members of that entity”. Pfeffer also advances a number of specific theoretical prepositions about the causes and consequences of demographic phenomena in organizations. In particular, he focuses on the properties of demographic distributions of persons in the focal organization, especially the length of service (LOS) distribution of members of the organization. Moreover, the heterogeneity in the LOS distribution affects organizational outcomes, such as the turnover (quoted by Carroll and Hannan, 2000).

NSI would include the subsystem research sector represented by universities, research laboratories, while the broad NSI includes many subsystems such as finance, firms, government, and so on. The efficiency of this broad NSI supports economic growth.

However, organizations are constructed complex entities, not biological organisms. This fundamental feature of organizations has main implications for certain aspects of organizational demography. Some approaches of human and biological demography can be borrowed, others require to be accommodated to social nature of organizations (Carroll and Hannan, 2000). In fact, demography of organizations should consider, according to Carroll and Hannan (2000), the following main differences between social organizations and biological organisms:

- Variety of events that define organizational births and deaths;
- Potential immortality of formal organizations that can persist as a social entity long after its initial members have departed;
- The lack of parentage for organizations;
- The intellectual (and organizational) rather than biological and genetic transmission of information and routines;
- Heterogeneity of organizational populations;
- The ability of organizations to change populations and transform themselves.

The demographic analysis of research organizations can be useful to analyze and predict their organizational behaviour and evolutionary change in order to improve the governance in turbulent and unstable environments caused by global economic recessions that affect the availability of public funds. Before to analyze the Italian national research council (CNR) by a demographic approach, it is important to describe its morphology (Ben-David, 1991) and then to discuss the demographic perspective of this research body, analyzing its organizational behaviour over time.

3. ORGANIZATION OF ITALIAN NATIONAL RESEARCH COUNCIL (CNR)

The focus of our analysis is the largest public research body of Italy, the National Research Council (CNR) founded in 1923 following the model of the German Kaiser Wilhelm Gesellschaft (now Max-Planck-Gesellschaft). As similar entities (Max-Planck in Germany,

CSIC in Spain and others), the CNR is organised in institutes operating in a large range of scientific disciplines and technological applications.

The morphology of CNR has been affected by Italian research policy, which has changed according to governments' changes. The first reform of CNR in 1999 was inspired by the idea to gain more efficiency through larger size of research units (consolidation). Although nowadays there are about 100 new institutes (in the past there were around 310 research units), these often have several decentralised units spread on the territory and far from the institute-headquarters. While this reform was still under way, after the political elections, the new government in 2003 decided to launch a new restructuring based on project management, with an explicit aim to transform the CNR in entrepreneurial body operating at the service of firms and other external users (Coccia and Rolfo, 2008). Common features of these reforms are the shrinking public research budgets for reducing high public Italian debt with a main consequence: now the public funds are no more sufficient to cover current expenses of public research units. In fact, the requirements for increased accountability of public funds, growing flexibility of research institutions to adapt to changing environments, and a better inclusion of socio-industrial objectives have led most countries, such as Italy, to change their research funding schemes. In the past, public funding enabled Italian scientist to carry out normal scientific activities and to apply for external projects for additional funding (Coccia, 2009). Nowadays, because of the decline of public funds, it is impossible to conduct research solely with public funding. Research institutes are forced to apply for market funds to conduct normal scientific activities. The market (external) funding is not just an additional, but also a main funding source for Italian public research institutes.

In this context, scientists have to adapt to low public funding conditions by several strategies for selecting external funds: targeting easy resources, targeting all resources and targeting appropriate sources (Laudel, 2006). Moreover, to increase the likelihood of external funding, scientists and structures change the content of

their research, diversifying research, avoiding risky research, avoiding hot topics, as well as supplying all technological services and consultancies demanded by external subjects. Moreover, the researchers spend a huge amount of time for technological services, for preparing grant applications, managing grants, and so on, reducing in this way the time for scientific research, which negatively affects the production of public research institutes (Coccia, 2009).

This strategic change of public research units is present not only in Italy but in several countries such as France (Mangematin *et al.*, 2006), Germany, Australia, Norway (Laudel, 2006), Spain (Sanz-Menéndez and Cruz-Castro, 2002) and so on. In fact, the objectives of this restructuring of public research institutions were to reduce general costs and to increase technology transfer and technological services supplied to firms and other users. In consideration of the widely shared political objective of improving scientific research production and technology transfer in public institutions of an industrialised country such as Italy, the organisational reforms of the CNR were designed in theory, since in practise they have been creating bureaucratization and coordination problems among researchers and research units (Coccia and Rolfo, 2007; 2008).

Moreover, national governments have reduced the hiring of research personnel with a real recruitment stop between 2001 and 2007. Three main consequences can be observed:

- Several lines of research as well as research units have been dismissed and/or downsized;
- Permanent researchers are forced to apply for more external funds in order to maintain a minimal junior research staff;
- A large amount of young researchers is now working in the CNR labs (as in the Italian universities) with different juridical status (generally short term contracts) and very low future perspectives.

4. METHODOLOGY FOR INTERNAL ORGANIZATIONAL DEMOGRAPHIC ANALYSIS

Data of this research are from CNR 2004

database of research personnel (CNR Report, 2007). The elementary unit used for the internal demographic analysis of this organization is the employee: i.e. researcher and technician.

The structure of personnel in organizations is a function of their history and as consequence of the hiring, retirements and migratory towards other organizations. First of all, it is calculated the pyramid of the research personnel per macro-regions, considering the age of research personnel.

Other main indicators applied are the rate of hiring and retirement per 1,000 research personnel, the subscripts t and x are years ($t > x$):

$$Hr_t = \frac{Hiring_{t-x}}{employees_t} \times 1000$$

$$Rt_t = \frac{Retirement_{t-x}}{employees_t} \times 1000,$$

The dynamic nature of research personnel in these organizations is represented by some graphs. In addition, the trends of research personnel are synthesised by some indices such as average age of personnel units, average age of hiring, number of hiring and the index of seniority (ISr) per macro regions given by:

$$ISr = \frac{Employees_{over50years}}{Employees_{30years-35years}} \times 100 \quad [1]$$

After that, the living function, called l_x , and the retirement function (d_x) are represented.

In addition, considering the function d_x , it is possible to find out the normal year of retirement R_x that is similar to the point of Lexis or normal age of death for human populations. This curve and point provide vital information in order to forecast the evolutionary behaviour of public research organizations over time.

In order to calculate the rate of growth of research personnel r , according to the exponential law, the following equation is applied:

$${}_tP = {}_0P \cdot e^{rt} \quad [2]$$

where e is the base of natural logarithm (2.71828...) and t is the time.

Therefore $\frac{{}_tP}{{}_0P} = e^{rt}$; $\text{Log} \frac{{}_tP}{{}_0P} = r t$;

$$r = \frac{\log \frac{{}_tP}{{}_0P}}{t} \quad [3]$$

The output of this demographic approach provides main results about the weaknesses and strengths as well as threats and opportunities of research organizations, that are the basis for supporting rational research policy aimed at improving their organizational behaviour over time. This demographic approach also offers an analytical framework for the organization theory and institutional analysis of public research labs.

5. RESULTS

The data of this research are the researchers and technical staff operating within the CNR at 2004. First of all, it is presented the structure of this organization per macro regions. The figure 1 shows that the older research personnel of the CNR is within the institutes operating in North and Central Part of Italy, because of the older history of these labs, vice versa the younger employees are in labs operating in South Italy and Islands (generally created since the '80s).

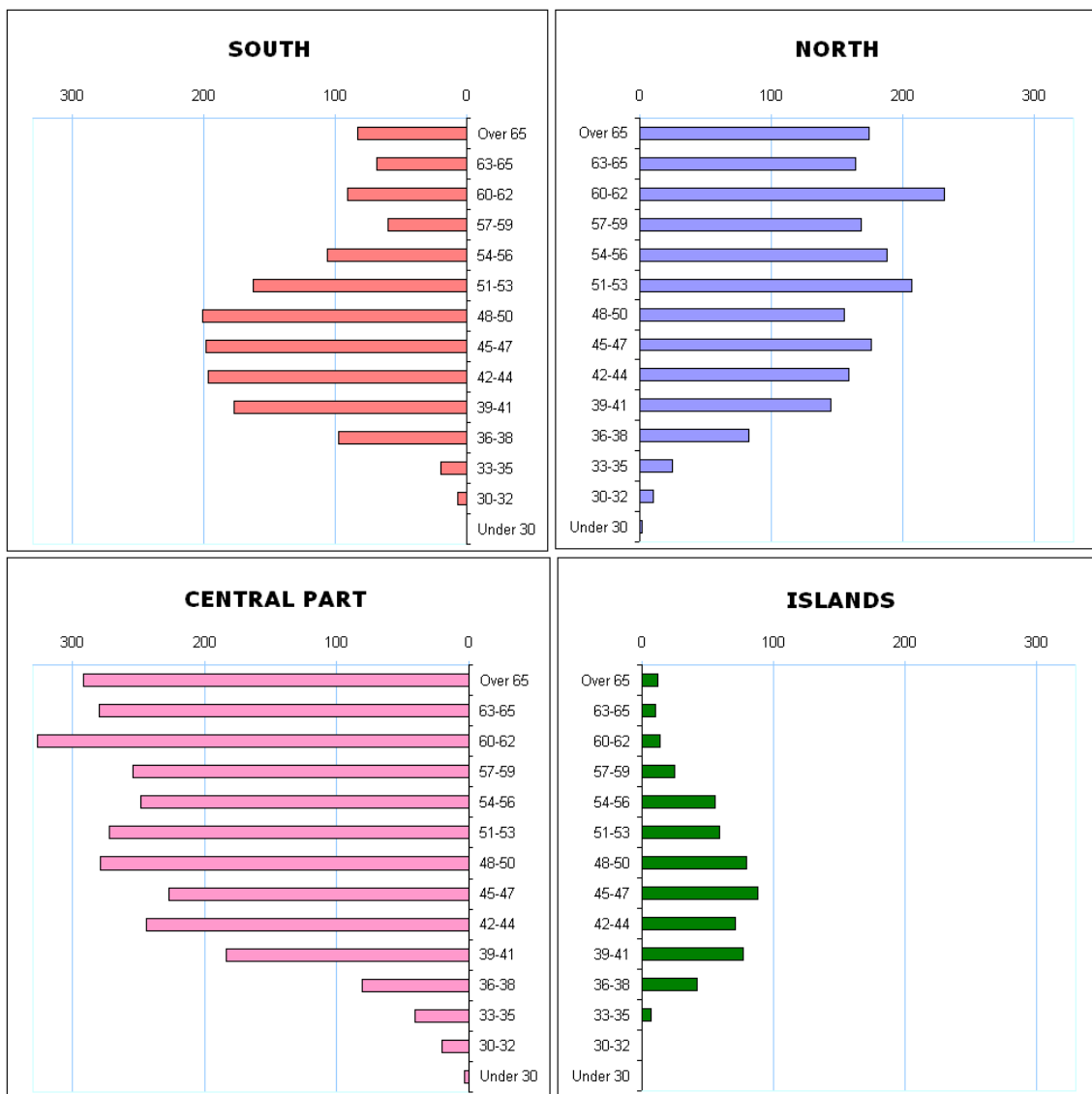


FIGURE 1: PYRAMID OF CNR RESEARCH PERSONNEL PER ITALIAN MACRO REGIONS (2004 DATA)

The structure of the research personnel in figure 1 and table 1 shows as the older research personnel in North Italy is also the most numerous population, whereas South Italy and Islands have a lower quantity of research

personnel, though younger. Living curve is in figure 2 and shows as, stopping hiring, the CNR will be closed in the 2044 year or thereabouts.

The regression line has a high goodness of fit ($R^2 = 0.982$).

TABLE 1: POPULATION OF CNR IN 2004

<i>Italian Macro regions</i>	<i>Researchers</i>	<i>Technicians</i>	<i>Total research personnel</i>
South	981	487	1,468
Central part	1,595	1,157	2,752
North	1,238	651	1,889
Islands	378	163	541
Total	4,192	2,458	6,650

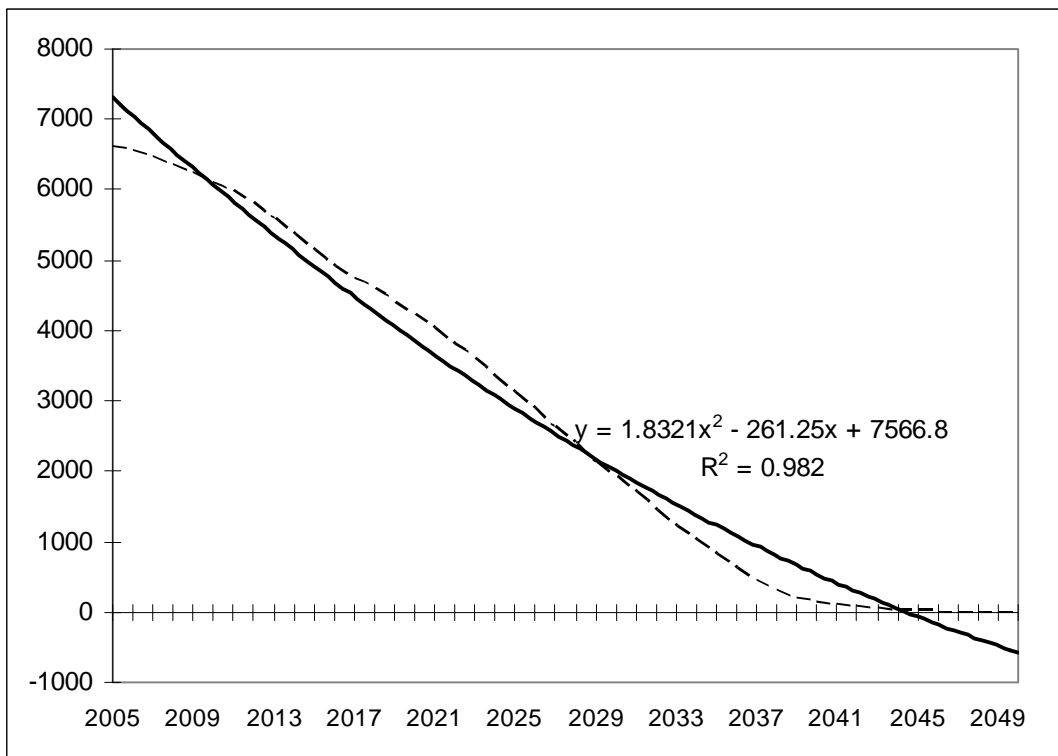


FIGURE 2: LIVING CURVE OF CNR L_x

Whereas, figure 3 shows as the hiring policy over the period 2001-2004 has pushed the living curve upward, increasing the forecast horizon of survival of CNR organization over time.

Instead, figure 4 shows two pseudo-Lexis points, at about 2015 and 2029 that indicate the highest number of retirements for the research personnel of the CNR. The figures 5 and 6 show the different demographic behaviour between researchers and technicians as far as retirement

is concerned. The first one, based on researcher, has the Lexis point after the year 2029 (Fig. 5), whereas the technicians have this point earlier: at 2015 (Fig. 6). Polynomial functions estimated with ordinary least squares method have high coefficients of determination (R^2) that confirm the goodness of fit. In addition, the appendix shows this organizational behaviour between male and female (Fig. 1A and 2A in appendix).

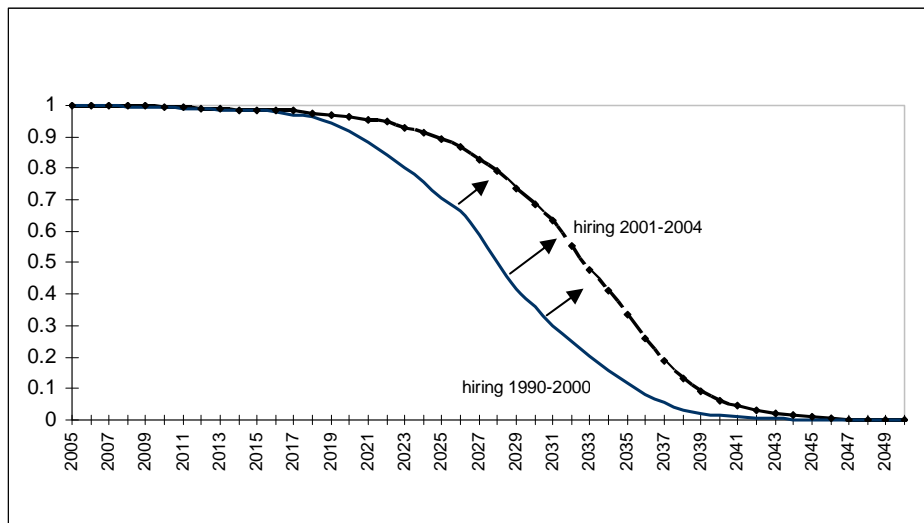


FIGURE 3: COMPARISON OF CNR HIRING POLICY OVER 1990-2000 VS. 2001-2004 PERIOD BY LIVING CURVE

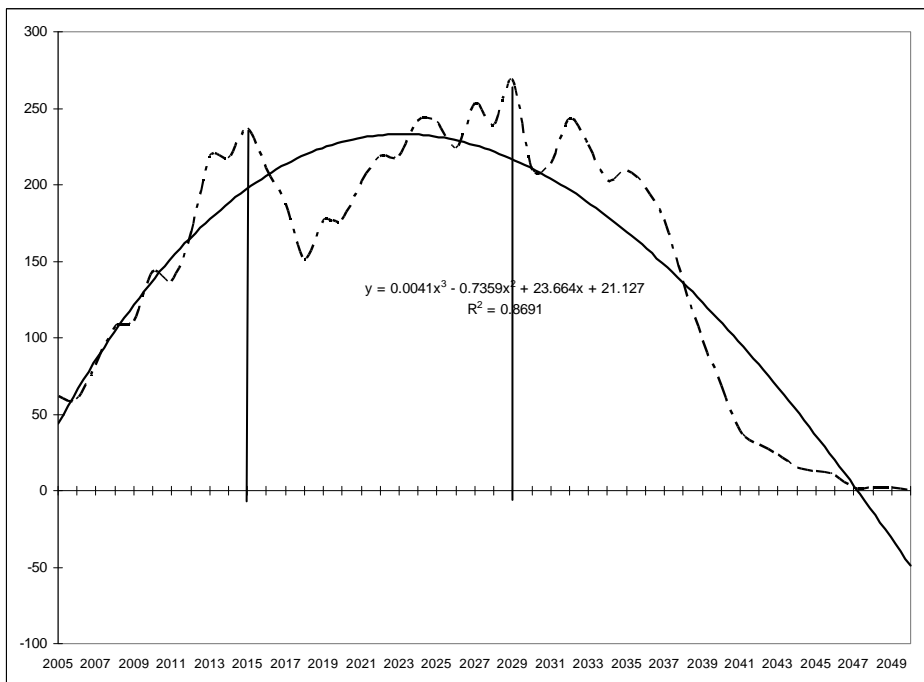


FIGURE 4: TOTAL RETIREMENT TREND OF CNR BY D_x CURVE

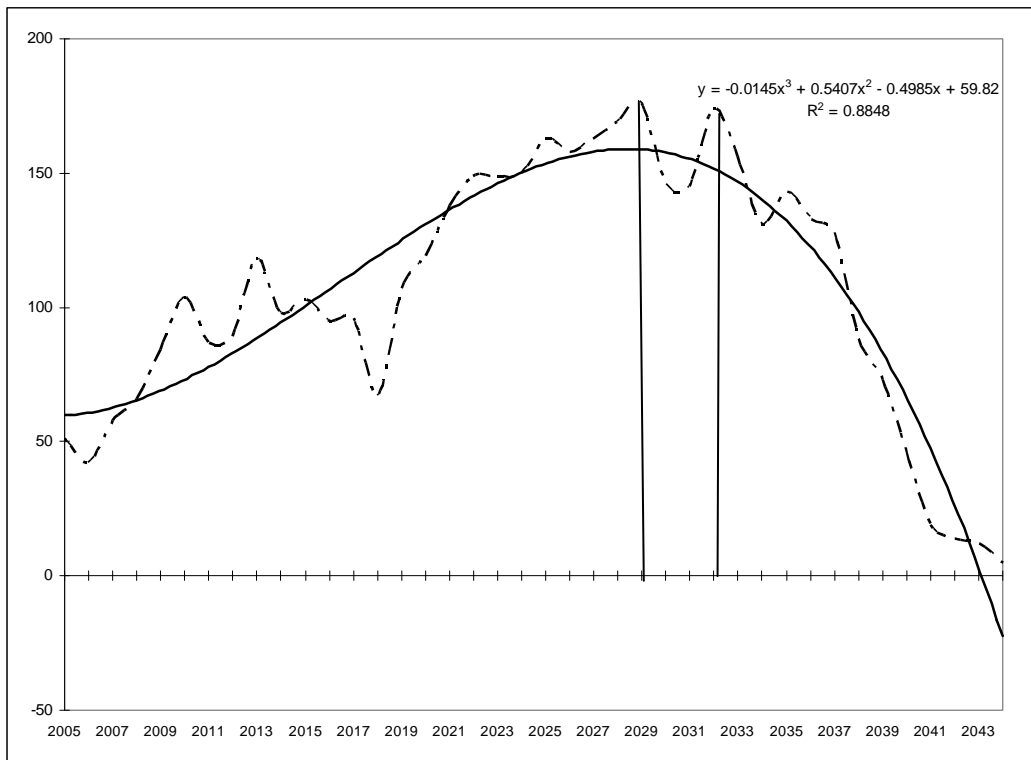


FIGURE 5: CNR RESEARCHER RETIREMENT TREND BY D_x CURVE

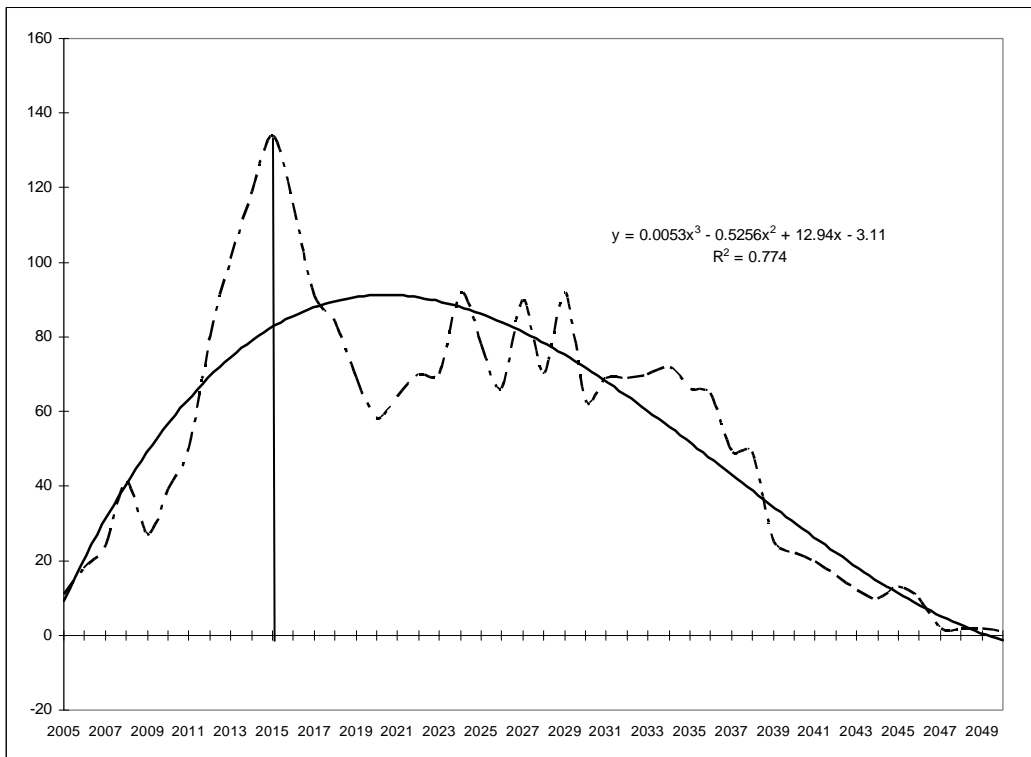


FIGURE 6: CNR TECHNICIAN RETIREMENT TREND BY D_x CURVE

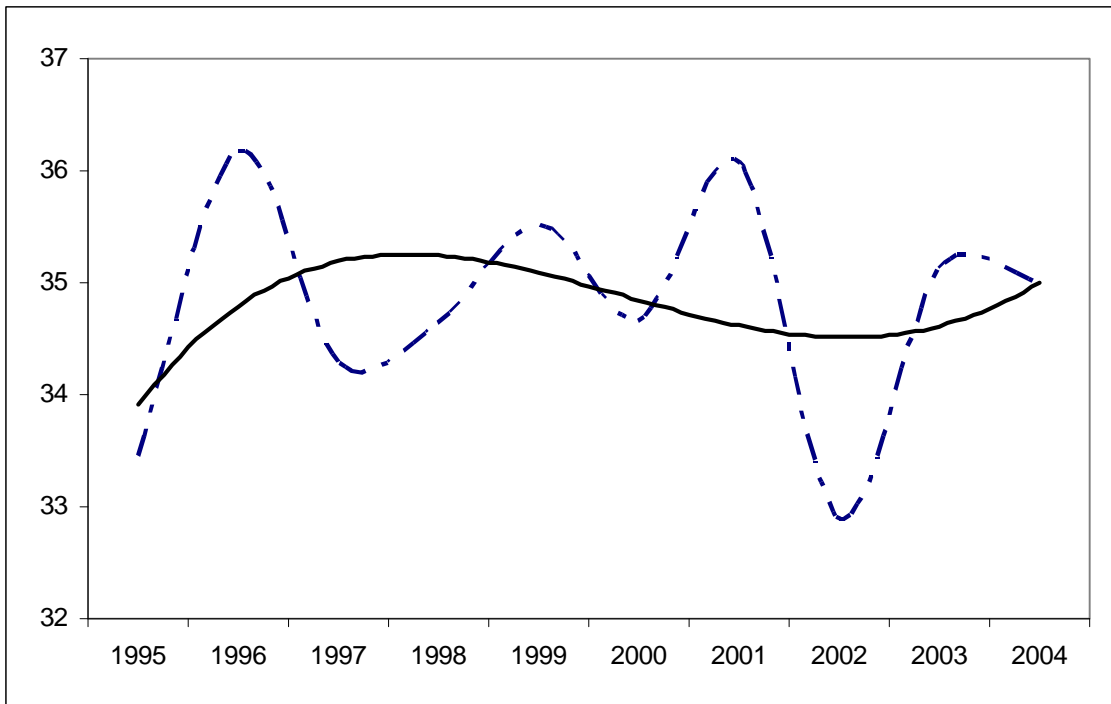


FIGURE 7: AVERAGE AGE OF CNR HIRING OVER 1995-2004 PERIOD

Figure 7 shows that the average age of hiring in CNR is about 35 year over 1995-2004, an older age considering that the high potential of researchers is when they are younger (Allison and Steward, 1974). In fact, Levin and Stephan (1991) analysing the publication productivity of scientists over their career life-cycles, find that, with the exception of particle physicists employed in Ph.D.-granting departments, life-cycle effects are present in the fully specified model that controls for fixed effects such as motivation and ability. Diamond (1986) also looks at life-cycle research productivity, and finds that the publishing activity of Berkeley mathematicians declines slightly with the age. In addition, Hull *et al.* (1978) show that older scientists are slow to adopt new ideas and may actually impede the progress of science by blocking innovative work of younger scientists. Therefore, current human research policy of hiring not younger research personnel reduces the scientific potential of the CNR and as consequence the future production of knowledge.

Moreover, if we consider a longer period, 1958-2004, the average age of hiring is about 31 years². The exceptional number of hiring in 2001 is formed by employees of about 36 years. In fact, these researchers were in the past research personnel with term contract (table 2). The figure 3A - in appendix - shows the hiring per year and sex and the local maximum represented by the hiring in 2001. The figure shows the typical cyclical patterns of public recruitment in Italian research institutions. These recruitment cycles are due to hiring-block in some years applied by governmental budget laws in order to reduce and /or slow down the huge Italian public debts. In addition the hiring-block has also two negative aspects: brain drain and adverse selection. In general the best researchers do not wait long term to be hired in public research labs and go towards foreign research labs/universities firms, generating a growing unidirectional *flow towards the most*

² This is because in the past, per law, the maximum age for applications in public administration was 30 years; now, since there are a lot of term contracts, this rule has been dismissed.

advanced countries (The USA and Europe essentially) that represent for Italy a net economic and scientific loss. The remaining researchers survive with short term contracts of public research labs, and in the *long run*, sometimes under the pressure of trade unions, they arrive to a tenured position in a very advanced age (more than forty-year-old). These hiring systems reduce the level of scientific quality in public research institutions with some negative effects in the production of scientific and technical knowledge and of the competitiveness of Italian national system of innovation in comparison to other countries.

Table 2 and 3 show that the men research personnel is older than female one, as well as technicians are an older population in comparison with researchers. In addition, table 3

shows the index of seniority [1] that confirms the older population in the research labs of Central Part and North Italy. Figure 8 shows the hiring and retirement over three periods. In general, the number of hiring is lesser than retirement, except the 2001-2004 period, when the population of CNR is increased. Although, this period of exceptional expansion of hiring, current trend of research personnel, using an exponential model of growth [2] and [3], is declining: in 1995 there were 7,451 employees, whereas in 2005 there were 6,945 research personnel units. This declining trend is mainly due to -18.15% of technical staff over 1997-2005 and -24.70% of administrative staff, although researchers have a $+1.37\%$ over 1997-2005 (Coccia, 2009a).

TABLE 2: DEMOGRAPHIC SITUATION OF CNR

	<i>Researchers</i>	<i>Technicians</i>	<i>Total units</i>
CNR 2009 (Number of employees)			
Male	2,643	1,787	4,430
Female	1,569	674	2,243
Total	4,212	2,461	6,673
AVERAGE AGE OF HIRING 1958-2004 (years)			
Male	32.5	29.4	32.3
Female	33.5	27.4	30.5
Total	32.9	27.9	31.1
HIRING IN 2001 (UNITS)			
Male	699	165	864
Female	583	123	706
Total	1,282	288	1,570
AVERAGE AGE OF HIRING 2001 (years)			
Male	36.7	34.9	36.0
Female	36.4	33.4	36.1
Total	36.5	34.0	36.1

Note: Data of administrative staff is not available

TABLE 3: SENIORITY INDEX OF CNR RESEARCHERS AND TECHNICIANS PER MACROREGIONS AND SEX (YEAR 2004)

<i>Macro region</i>	<i>Researchers</i>		<i>Technicians</i>		<i>Men</i>		<i>Women</i>		<i>Total</i>	
	<i>Seniority index 2004</i>	<i>Seniority index 2004</i>	<i>Seniority index 2004</i>	<i>Average Age years</i>	<i>Seniority index 2004</i>	<i>Average Age years</i>	<i>Seniority index 2004</i>	<i>Average Age years</i>	<i>Average Age years</i>	<i>Average Age years</i>
North	2.29	48	3.88	49	3.91	49	1.03	45	2.71	48
Middle Part	3.44	49	3.52	48	4.58	50	1.82	46	3.47	49
South	0.65	43	1.67	46	1.53	46	0.32	42	1.00	44
Islands	0.45	43	0.21	42	0.47	43	0.19	42	0.34	43
Total	1.92	47	2.55	48	3.05	48	0.94	45	2.15	47

Note: Higher value of seniority index means older CNR research personnel over time

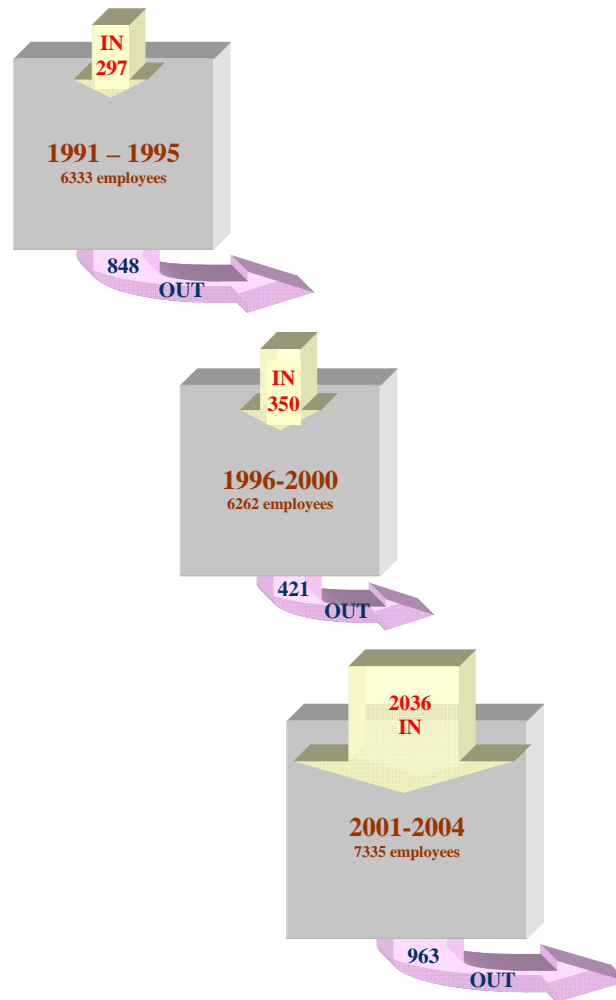


FIGURE 8: TURNOVER OF THE CNR OVER TIME

6. LESSONS LEARNED AND CONCLUDING REMARKS

The main lessons learned by this demographic analysis applied to Italian CNR are:

- The greater number of research personnel operates in Central part and North Italy and it is older than South Italy and Islands (irregular distribution of human resources);
- The average age of hiring is about 35 years over 1995-2004 for researchers, an older age considering that the high potential of researchers is when they are younger;
- Men research personnel are older than female one, as well as technicians are an older population in comparison with researchers;
- In general, the number of hiring is lesser than retirement, except the 2001-2004 period;
- Current trend of research personnel is declining: in 1995 there were 7,451 employees, whereas in 2005 there were 6,945 research units. This declining trend is mainly due to -18.15% for technical staff and -24.70% of administrative staff over 1997-2005;
- Current human resource policy of Italian governments fosters the brain drain and a potential adverse selection;
- Pseudo-Lexis points indicate the highest number of retirement for the research personnel of CNR over time: researchers have the pseudo-Lexis point after the year 2029 or thereabouts, whereas technicians at 2015 or thereabouts (i.e. year of the highest number of retirements).

These results show how the new public management of research bodies applied by Italian Governments has been affecting in negative way the evolutionary change of research units, generating problems for the furthering of research. This negative trend is mainly due to low public funds for research sector generated by high public Italian debt and expenses in a period of global economic downturn that affects the public budget. This strategic change of research unit is functional to cope with environmental threats and market turbulence. Moreover, the origin of this situation in Italy is the lack of a long-term national research strategy and of a consistent research policy (shared by Italian governments of different political coalitions), which has been generating structural deficiencies and negative performances of the whole Italian national system of innovation as well as economic system, in terms of low GDP growth rates, productivity, competitiveness of firms and long-run economic growth (Coccia, 2005). Therefore, the hasty and uncertain Italian research policy has been creating problems of structural deficiencies within the research organizations. To sum up, current Italian research policy is not a sustainable strategy for long-term scientific objectives! In particular, unless this public management of research units, based on a myopia of short-run commercial targets (massification)³ rather than long-run scientific goals, is halted soon, important portions of scientific knowledge will be in the future horizon of private property and fall outside the public domain, slackening future progress of science and technological progress.

This analysis focused on Italian case study cannot be transferred directly to other countries, even if the worldwide tendency in research sector seems to be parallel in several countries, since globalization generates global economic

³ Because of market-oriented trends of research units - due to low public funds- they are focused on massive increase in technological services rather than fundamental research, therefore there is depersonalisation of researchers and emptying of the scientific research activity of its main contents: i.e. less discovery-based research around longer term needs centred on public welfare; in other words, business and commercial interests are influencing research units and universities in an unsavoury manner, see Musselin, 2007; Schuetze, 2007.

recessions and financial problems across countries such that affect public funding of universities and public research bodies. The threat is that basic research and knowledge will be reduced in future since certain types of basic research institutions will be disadvantaged everywhere and might become 'endangered species in science environmental'. These results are a critical basis to a great extent relevant to policymakers in order to support the correct strategic and evolutionary change of public research units in knowledge era.

In fact, the governments have to be aware of the risk of hasty reforms and myopia of current research policies aimed at increasing commercial targets in the short-run rather than leveraging the scientific and technological growth of these institutions in the long-run that have to underpin future wealth of nations. Therefore, it is important that researchers help the governments and public management to support their decisions in order to sustain an evolutionary change and fruitful adaptation of these public research institutions in turbulent environments. This demographic and evolutionary analysis provides main results for public management even if the analogy between human populations and organizations is noticeable, although may be a forced approach in some cases. No doubt that to support provident science policy, further research about the new western-style organizational behaviour of public research institutions is needed to strengthen this important topic in economic and managerial literature in order to improve the governance of research units that has, more and more, a driving role for modern economic growth patterns based on intangible capital.

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APPENDIX A: HIRING AND RETIREMENT TRENDS PER SEX

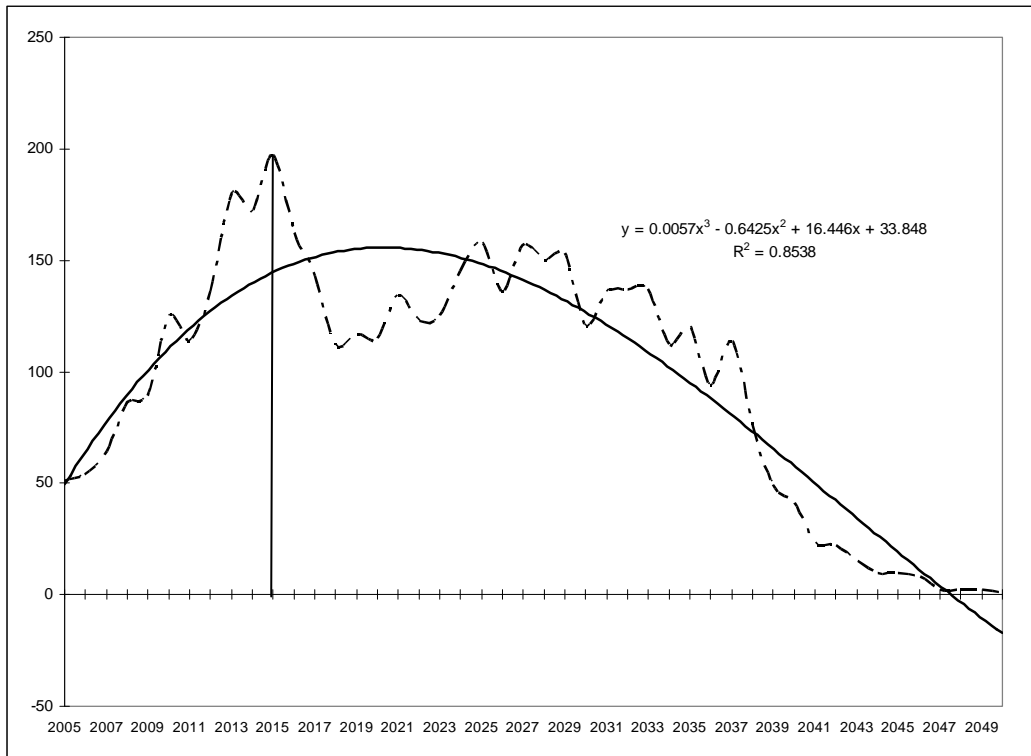


FIGURE 1A: CNR MALE RETIREMENT TREND BY D_x CURVE

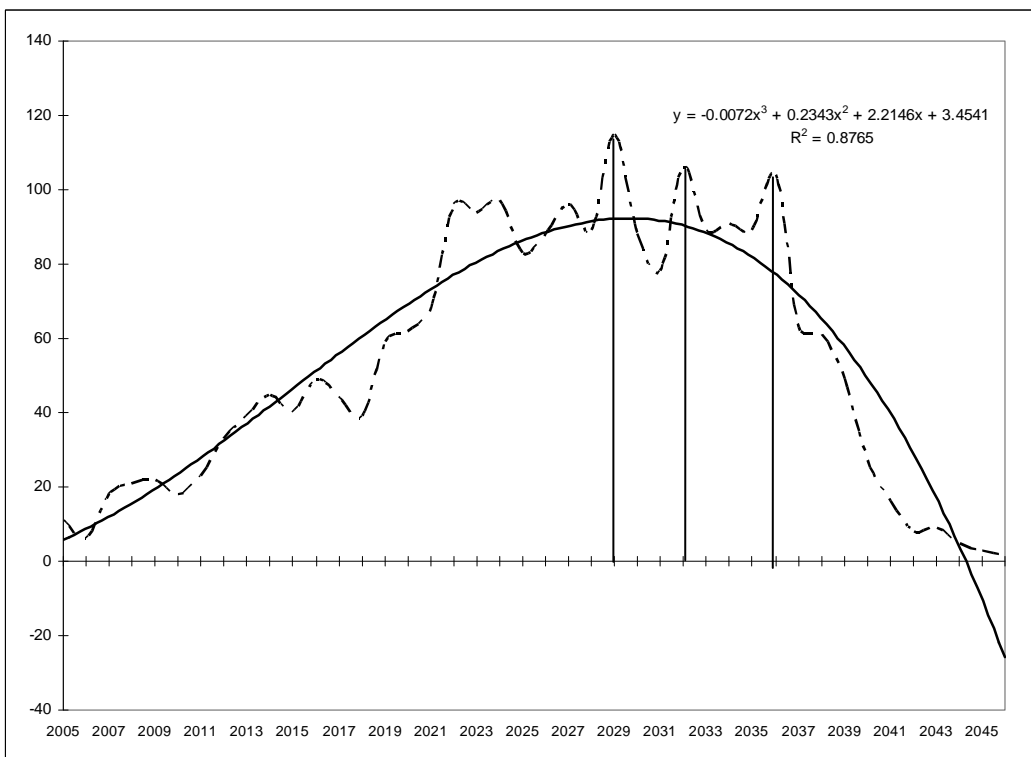


FIGURE 2A: CNR FEMALE RETIREMENT TREND BY D_x CURVE

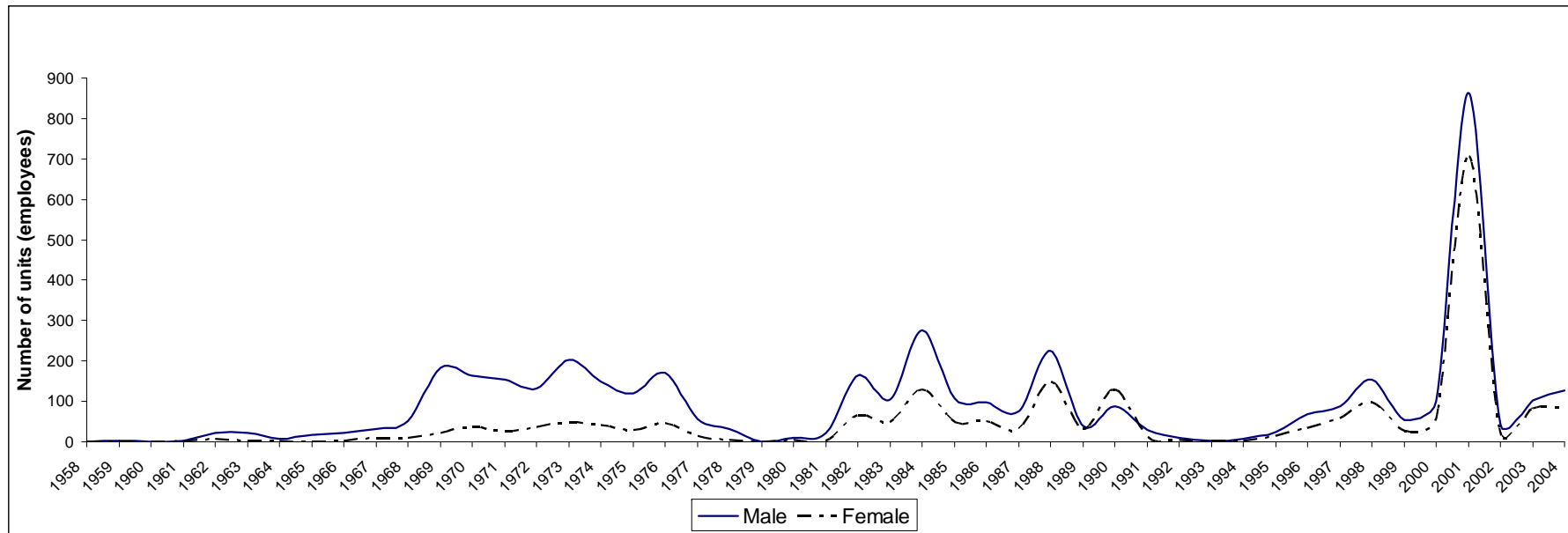


FIGURE 3A: NUMBER OF HIRING PER YEAR AND SEX IN THE CNR

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