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Through the eyes of industrial researchers: how new "Connect & Develop" practices change the role of human resources in the lab

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ABSTRACT: An intense debate is going on about more "open" strategies that are supposedly diffusing in industrial R&D. We here discuss the relationship between such practices and Human Resources Management (HRM) in industrial R&D Labs. The paper in fact aims at representing an original attempt of looking at the linkage between R&D strategy and HRM in some Italian high-tech firms. In particular, we identify, select and discuss a set of variables related to the management of HR in R&D that fit with the reconceptualization of innovation proposed by Chesbrough in the "Open Innovation" (OI) paradigm and inspired by the example of P&G's model of Connect and Develop (C&D). More precisely, our objective is that of investigating the role of HRM in the shift towards "Open Innovation" through the bottom-up lenses of industrial researchers' characteristics, feelings and behaviours. What we here suggest is that by observing behaviour and expectations of R&D workers, we can investigate the acceptance and implementation of new R&D management practices.

Our empirical base is represented by 330 questionnaires completed by R&D personnel and collected through an online survey. The results have been discussed with the HR managers of each company, in order to also gain a "top-down" perspective on the observed dynamics. The research is carried out around three main groups of issues: HR characteristics (e.g., demographic parameters, productivity, time horizons, satisfaction, expectations, mobility, education), job organization aspects (e.g., teamwork vs. individual research, flexibility, decisional centres, work time allocation, type of relationships, communication flows), and HRM tools (e.g., talent attraction, training, evaluation methods, goal definition, roles, leadership, responsibility, incentives, career systems, problem sources). According to Chesbrough, firms fitting the OI model present characteristics related to the R&D structure itself. Nonetheless, even if this model has been widely enthusiastically discussed and sometimes criticized by both practitioners and researchers, we still lack a comprehensive understanding of how such changes effect dynamics and daily operations of an R&D lab. Our empirical analysis ultimately aims at understanding to what extent the shift towards an extended definition of R&D, which includes the new concept of C&D, can be considered as one of the main potential factors of change in HR organization. Beyond the relevance of our findings for the debate among scholars, we argue that managerial implications may derive from a better knowledge of individual perceptions and behaviours of R&D personnel. In fact, the changing pattern of innovation processes implies parallel changes in the organization of R&D labs, where the role of the most important component, i. e. researchers themselves, is not always adequately considered. This paper is a first attempt to explore these relationships. Through a convenience sample we first attempted to test various strategies to best collect data, provide timely valuable feedbacks to our industrial partners and better define our framework, matching early results with existing theories. Further research will aim at making the sample representative of the Italian industrial R&D system.

1. Introduction

The increasing value of human capital makes people operating in R&D laboratories a crucial asset, especially for knowledge-based firms. Nowadays, human resources are among the most valuable assets of an innovative organization since they play a fundamental role in the creation of competitive advantage through technological leadership. R&D workers – scientists, engineers, and other technical personnel – have to be attracted, motivated and retained in order to reach high levels in the productivity of new ideas and products/processes. Since high performance in R&D seems to depend on having top-notch, motivated individuals on board (Jordan, 2005), it is crucial for managers to understand which are the trends emerging in this specific field of management (Szakonyi, 1994)[1]. Nontheless, surprisingly, there are not so many empirical studies analysing the ways in which Human Resources Management (HRM) in R&D works effectively.

A few authors specifically explore industrial

[1] According to Szakonyi (1994), "Although nearly everyone involved in managing industrial companies believes R&D should play a vital role in sustaining and growing a company's business, only a small percentage of companies have world-class R&D Management. The problem usually stems from a significant gap between management's desire to exploit the results of R&D and its knowledge of how manage R&D effectively".

researchers' behaviours and feelings in a systematic way. The psychological aspects of the motivation of workers are deeply discussed by authors such as White (1959), Lawler and Porter (1968) and Costa (1992); Lawler and Porter in particular elaborate the "Expectancy Model", extending the earlier model developed by Victor Vroom in 1964 and investigate relationships between personal satisfaction and productivity, but their perspective is general and not distinctively referred to R&D personnel.

Greater emphasis in the literature is given to teamwork, with a higher number of articles; among them, Barczak and Wilemon (2003) analyse the role of teams in new product development, while Grabher (2001) focuses on knowledge sharing, which facilitates knowledge absorption and integration; Creed and Miles (1996) discuss about reciprocal trust and learning processes and Cooper and Kleinschmidt (1995) consider cross-functional teams as success factors. More recently, a study on communities of practice has been performed by Frost and Holzwarth (2002).

Interaction among researchers was treated in the seminal work by Allen (1971), who first differentiated between two kinds of R&D workers: scientists and engineers. Ten years later Roberts and Fusfeld (1981) proposed a more detailed taxonomy of critical roles of the innovative process in which they identified a number of profiles operating in R&D with specific competencies and tasks.

Other studies, such as those by Roth (1982) and Allen and Katz (1986) regard career paths and the dual ladder system, which have been extensively analysed (Shepard 1958, Roth 1982, Allen & Katz 1986, Costa 1992, Cha & Kim 2000) and criticized (Goldner & Ritti 1967, Kaufman 1974, Dalton et al. 1977).

However, these studies do not adequately take into account the recently defined emerging concepts of Open Innovation (Chesbrough, 2003)[2] and Connect and Develop (C&D)[3], that seem to increase the complexity of the innovation paradigm, even if Dahlander and Gann (2007) express doubts about the real novelty of these conceptualizations. Although some authors have already written about this issue, such as, for example, Love and Roper (2002) and Cassiman and Veugelers (2006), who wrote about complementarities between internal processes of innovation and external knowledge, there is still a lack in understanding the specific micro-level changes brought by the adoption of open models of innovation on researchers' behaviours and the effects of these on the management of HR in industrial R&D.

Practitioners and HR managers argue that stimulating and managing R&D professionals are activities which are increasingly harder to plan and implement due to the complexity and novelty of the multiple roles that researchers have to understand and play doing research in more open environments. HR managers are in fact facing an increasing volume of issues related to openness: from the attraction and retention of the talents who are more suitable for "open research", to the management of communication flows among researchers, among subsidiaries and so on. R&D workers fitting the C&D paradigm are asked to act like "porous sponges" absorbing external inputs of innovation to be transformed and improved inside company's labs; to do this they have to interact with a large number of interlocutors and adapt frequently to the changing conditions of the business environment.

Maybe some R&D workers' relevant characteristics should be redefined, since playing the game of innovation requires a set of skills which is broader than in the past, bringing researchers' ideal profile somehow closer to that of a decathlete. This is why a deeper view of what is really perceived by R&D workers seems now particularly useful.

2. Methodology

We analyze the trends in HR in R&D with a bottom-up perspective, based on a set of 53 questions posed directly to more than 330 individuals currently working into industrial R&D laboratories of Italian high-tech firms[4]. The sample includes small, medium and large firms, but so far data have been analysed without any distinction by firm size, sector or location[5]. It is "through the eyes of industrial researchers" that we aim at better understanding the dynamics of change that open models of innovation have brought in R&D.

We collected industrial R&D workers' perceptions by using an online survey platform specifically configured for this purpose. The web-based collector system gave us the opportunity to monitor data entry errors, improve clearness and obtain a high completion rate. Moreover, the growing dataset of answers has been available for real-time comparisons and benchmark tuning.

After each set of interviews we discussed company-related results with HR managers in order to obtain additional top-down perspectives and eventually adjust or better define some variables of the questionnaire. The primary objective of the construction of a database made with answers rigorously not filtered by managers' views has been confirmed. The "pureness" of results allowed us to select the most critical values perceived by R&D workers (i.e. strengths and weaknesses of the firm) without indulging on managers' points of view, which sometimes differ from those of R&D personnel. We then compared company level data with the "benchmark" mean values of the entire population observed in order to give -

[2] An Open Innovation oriented company is seeking resources and ideas beyond its corporate borders, and is exploiting the results of its R&D investment not only through new products and services but also through other forms of commercialization.

[3] For more details about the C&D Model see also Huston, L. and Sakkab, N. "*Connect and Develop: Inside Procter & Gamble's New Model for Innovation* ", Harvard Business Review, pp. 58-66, March 2006

[4] Data collection started in autumn 2007 and is still in progress: data presented in this paper are the first results emerging from the analysis of the current sample of answers collected.

[5] These distinctions may be relevant for a further research but we will not focus on them in this preliminary analysis

in a relatively short time - reliable feedbacks to firms participating to the research[6].

After a first raw selection of the most interesting elements to analyse, we calculated standardized values for each variable, obtaining comparable items. Variables were then divided into 3 main groups: "A", "L", "R". Each standardized variable is marked with the prefix "Z", followed by the group identification letter.

Group "A" identifies **firm-related variables** such as those referred to sources of conflict, decision makers, task planning, career system, training methods, incentive system, valuation methods and strengths and weaknesses of the company.

Group "L" contains **labour-related variables** expressing working time flexibility, time allocation, R&D time horizon, team size, stress factors, people remote and face-to-face interaction.

Group "R" is referred to **researchers' profile**, which includes variables such as age, sex, seniority, number of patents and publications, past experiences, skills, education, mobility, personal goals, interests, entry and exit modes in and out of the firm, expected rewards, preferred incentives, motivation factors, satisfaction sources and R&D success key factors.

The analysis of the elements cited before was done in three different ways: 1) statistical evidences about the main variables of each group, in order to identify particular trends and mean values; 2) correlation matrix of the whole set of variables, to obtain information about relationships that have at least 95% statistical significance; 3) factor analysis addressed to recognize the most relevant motivation, satisfaction and success factors deriving from positions expressed by R&D workers who take part in the survey.

In the next section we will present the preliminary results of our study. We first identify the general trends coming from the correlation analysis and we then focus on the results of the factor analyses.

3. First general results of the study

We here identify some general trends from our first analysis. Data collection and analyses are still in progress and evidences cannot be considered as representive of the Italian industrial R&D system. They rather are here presented to exemplify the analytical possibilities of the methodology that we have designed. This section therefore offers some preliminary results, organized as follows.

In paragraph 3.1 we examine conflicts and stress factors; among them we identify the lack of responsibilisation and involvement that led us to investigate the decision making process and the particular role of teams in this (paragraph 3.2). Since we consider teams as key factors of the innovative capacity of the open firm (i.e. one which widely adopts Open Innovation and C&D practices), we then explore more in details some specific aspects such as team size, team composition and the degree of internationalization of members (paragraph 3.3). In paragraph 3.4 R&D workers are considered with respect to their skills and attention is paid to business consciousness and interactions abilities.

Training methods and objectives are discussed in paragraph 3.5, while the following points describe the incentive system (3.6) and the planning activity (3.7).

The sample taken into account is characterized in gender by the prevalence of male researchers (89,2%), age range is from 24 to 60 years and education background is on average including the Italian "Laurea" degree, but only 7% of the population interviewed has a PhD degree.

In our sample we do not find significant correlation between age, education, gender and the other variables in our survey. As the sample will grow bigger and more representative we assume that these dimensions will help cluster observations according to these basic descriptive. On the contrary, in the following sections we mention the most remarkable issues which seem to have some relevance. We here look at relationships among variables, expressed by correlations, like trends that approximately describe "in a sketch" the larger puzzle we are investigating.

3.1 Conflicts and stress factors

R&D workers were asked to judge on a scale from 1 (minimum) to 5 (maximum) various sources of conflict in the company (a_conf* variables) and the main stress factors personally experienced (l_stress* variables).

Sources of conflict in the company are synthesized by a set of 4 items: manager misunderstandings (a_conf _dir), other sources of conflict generated within the team (a_conf_taltro), communication among team members (a_conf_tcom), goal definition with team members (a_conf_tob).

Stress factors experienced by R&D workers are defined as: conflicts with team members or managers (l_stress_conf), pressures to obtain results (l_stress_ris), time constraints (l_stress_tempi), customers relationships (l_stress_tencli), team relationships (l_stress_tensteam).

Tables 3.1-1 and 3.1-2 show results obtained (missing data deriving from "no answer" were deleted from the panel).

Variable	Obs	Mean	Std. Dev.
a_conf_dir	294	2.105442	1.126369
a_conf_tal~o	290	1.731034	.8585428
a_conf_tcom	299	1.963211	.9133523
a_conf_tob	300	1.99	.9554806

Tab. 3.1-1

Analysing descriptive statistics, we observe a relative low level of internal conflict in the panel, with average

[6] The mechanism, acting like an incentive, gave us the opportunity to convince managers to accept their employee to submit the questionnaire, whose compiling time is estimated 30 minutes per person, so that it represents for the firm a sort of investment.

values around 2 on a 1 to 5 scale.

Variable	Obs	Mean	Std. Dev.
l_stress_c~f	302	2.254967	1.134432
l_stress_ris	297	2.86532	1.115936
l_stress_~pi	305	3.531148	1.132583
l_stress_~li	285	1.821053	1.003293
l_stress_t~m	303	1.877888	.9107195

Tab. 3.1-2

In the field of stress factors regarding the personal sphere of R&D professionals, time constraints are the most critical ones (avg = 3,53), followed by the pressure to obtain results.

The analysis of the correlations among all the variables extracted from the survey suggests the following remarks:

- researchers with wider economic knowledge are more likely to criticise managers, and; ρ (zr_ski_bplan, za_conf_dir) = 0,31;
- technicians convinced that dual ladder career system is useful have more conflicts with managers; ρ (zr_dc_escl, za_conf_dir) = 0,29; ρ (zr_dc_arc, za_conf_dir) = 0,282;
- pressures to obtain results and respect time constraints increase internal conflicts; ρ (zr_stress_ris, za_conf_dir) = 0,24; ρ (zr_stress_tempi, za_conf_tcom) = 0,222;
- positive correlations among za_conf* variables and zr_lavest, zr_mot_obchiari, zr_autore, zr_age, zr_exit_car, zr_mot_resp, zr_mot_coinv, zr_expremi_car indicates that senior researchers who worked abroad and published articles enter mre frequently in conflicts with managers and are more oriented to abandon the firm if they are not adequately listened to; they ask for transparency and higher responsibilities in decision processes and career advancements;
- researchers who experienced specific education paths are very likely to get in conflict with other team members; ρ (za_for_altro, za_conf_team) = 0,783;
- researchers working individually and people fully immersed in R&D activity *strictu sensu* are less in conflict with other people; ρ (zl_time_rs, za_conf_dir) = -0,156; ρ (zl_time_rs_ind, za_conf_tcom) = -0,165; viceversa, the higher is the number of members of the team, the higher is the probability of conflict: ρ (zl_teamsize, za_conf_team) = -0,197 ;
- dissatisfaction is an important source of conflicts, especially when researchers are not enjoying their work (ρ (zr_ok_lavoro, za_conf_dir) = -0,197) or their salary (ρ (zr_ok_retrib, za_conf_team) = -0,173) or, in general, the sense of personal growth is low: ρ (zr_ok_crescind, za_conf_dir) = -0,2;
- conflicts can be reduced through good leadership (ρ (za_sw_leader, za_conf_dir) = -0,212) and tutoring (ρ (za_for_tut, za_conf_dir) = -0,179);
- better task planning and roles definition limit conflicts, especially those with managers; ρ (za_pianificaz, za_conf_dir) = -0,244;
- cosmopolitan teams are more likely to generate conflict situations among members: ρ (zr_cosmo, za_conf_team) = 0,253.

The next step of our research will be grouping these results to create more exhaustive synthetic variables defining profiles for researchers, firm climate and management dimensions. In the meanwhile, we can argue that the more researchers are self-confident, prepared and interested in obtaining career advancement or, in general, dissatisfied with their work and salary, the more they are likely to start conflicts with colleagues or managers.

Open environments, often characterized by larger teams, composed by people coming from other countries or with experiences abroad, are more at risk of conflict than closed ones, probably due to the higher number of interactions among different researchers.

Greater responsibilities and involvement of senior and talented researchers, combined with managerial leadership and goals transparency can be a good strategy to prevent conflicts. The environment should promote collaboration to reach technological excellence: tutoring can play a role in improving relationships among researchers, increasing the sense of personal growth and mitigating the risk of misunderstandings. Best performing researchers have to be listened to and promoted on the basis of a clear career system when necessary, in order to prevent abandons. Time constraints remain the most serious stress factors for R&D workers: better task planning can reduce it.

3.2 Decision makers: the role of teams

Variables named a_ dec* refer to three types of decision makers. More precisely, the purpose is to understand who are the most influent people on decisions that effect team work: a_dec_dir is referred to managers, a_dec_glead to team leaders and a_dec_team to all the team. The a_dec_dir mean value (avg = 4,23) clearly suggests decisions are taken mainly by managers even if a significant role is also played by group leaders, who probably report the sentiment of the whole team, whose direct involvement in decision making is weaker but not less important with many respects.

Variable	Obs	Mean	Std. Dev.
a_dec_dir	306	4.238562	.9676488
a_dec_glead	306	3.748366	.919059
a_dec_team	306	3.316993	1.119502

Tab. 3.2-1

The correlation matrix of all the standardized variables taken into account in this paper suggests in fact as follows:

- firms with researchers interested in publishing have managers who are more likely to delegate researchers to take decisions; ρ (zr_intpub_az, za_dec_team) = 0,418;
- firms with more intense interaction with suppliers are more likely to give teams importance in the decision making process; ρ (za_sw_colforn, za_dec_team) = 0,354;

- the better the team leader the higher his influence on decisions; ρ (zr_sod_tlq, za_dec_glead) > ρ (zr_sod_tlq, za_dec_dir), ρ (zr_sod_tlq, za_dec_team)
- team involvement in decisions effects positively the corporate atmosphere and the sense of belonging; ρ (za_sw_atm, za_dec_team) = 0,415; ρ (zr_ok_sensoap, za_dec_team) = 0,324;
- when teamwork is a key element of the organization, team members are involved in decision making; ρ (za_sw_team, za_dec_team) = 0,333;
- collaborative teams are more likely to be listened and this positively effects satisfaction and creates a good atmosphere; ρ (zr_sod_climateam, za_dec_team) = 0,3;
- team leader is rarely taken into account for decisions related to R&D characterized by a short time horizon, ρ (zl_oriz_breve, za_dec_team) = -0,145;
- technological excellence is positively related to team involvement; ρ (za_sw_eccel, za_dec_team) = 0,394;
- face-to-face meetings between team members and managers are more frequent when team has a role in decision making; ρ (zl_f2f_dir, za_dec_team) = 0,341;
- managers are likely to reduce their weight in decisions when researchers have adequate economic competencies; ρ (zr_ski_bplan, za_dec_dir) = -0,238.

On the basis of these evidences we can argue that even if the data show that it is confirmed that the role of the decision maker is traditionally played by managers, teams and firms that have the characteristics of Open Innovation are more likely to give higher responsibility to researchers working in teams. By one side, this increases the flow of information within the firm with tangible benefits on the effectiveness of the decision process, by the other side it reinforces the acceptance of the strategic guidelines by R&D workers and improves the working atmosphere with positive effects on satisfaction and the sense of belonging to the firm. Decision sharing is particularly useful when researchers collaborate with external subjects (i.e. suppliers) or are asked to publish articles, probably due to the leveraging opportunity of the better knowledge they acquired in external relationships. Since technological excellence seems to be positively related to team involvement, a team-based organization with strong group leaders and business conscious researchers will fit with this winning profile better than a more closed individual-based R&D activity, necessarily guided by managers' views due to the higher fragmentation and lower importance of teams.

3.3 Team size, composition, internationalization

Since teams are normally considered as key factors of the innovative capacity of the open firm, we investigated their basic characteristics. The average number of people grouped in a team operating in a R&D lab has resulted equal to 10, while the percentage of cosmopolitan teams was only around 8% of the total.

Although correlations among zl_teamsize (number of members composing the research team), zr_cosmo (expressing the presence of foreign researchers in the team) and the whole set of variables are not very strong, we observed the following possible trends:

- large teams seem to stimulate publishing; ρ (zr_pub_naz, zl_teamsize) = 0,2;
- young researchers usually work in small teams and think incentives should be based on team results rather than on individual or company-wide results.; ρ (zr_assuny, zl_teamsize) = -0,209, ρ (zr_basinc_risteam, zl_teamsize) = -0,125;
- explicit R&D goals are important for success in cosmopolitan teams (ρ (zr_suc_obesp, zr_cosmo) = 0,252);
- cosmopolitan teams are more likely to be composed by people with previous experiences in other firms (ρ (zr_numaz, zr_cosmo) = 0,19);
- researchers who work in cosmopolitan teams are less satisfied about the incentive system (ρ (zr_ok_premi, zr_cosmo) = -0,188) and about work in general (ρ (zr_ok_lavoro, zr_cosmo) = -0,203).

If we consider R&D professionals who worked abroad (zr_lavest), they seem to be more inclined than others towards taking part to international activities such as projects (ρ (zr_progint, zr_lavest) = 0,266) and publications (ρ (zr_pub_int, zr_lavest) = 0,287) and they are readier to move abroad again even for middle-long periods (ρ (zr_trasf_m, zr_lavest) = 0,227). Also, they seem to be good planners, able to write tech and business plans better than others (ρ (zr_ski_tplan, zr_lavest) = 0,263), and better market analysts, leveraging their curiosity and comparison inborn characteristics.

In synthesis, junior researchers are introduced to R&D in small teams, where they appreciate workgroup and consider team results as natural parameters of evaluation.

Senior scientists seem to be more involved in publishing activities. They usually work in larger teams. International activities are carried out better by cosmopolitan groups, made with open minded people who lived in foreign countries acquiring good knowledge of English and planning skills. They are also more disposed to go abroad again if necessary.

Not surprisingly, people coming from different contexts risk to clash with rigid and closed systems: this means lower satisfaction of work. R&D managers should try to give them customized incentives and fix rules with transparency, specifying clearly the goals to achieve.

3.4 R&D workers' key skills: business consciousness and interactions

According to descriptive statistics about researchers' skills (zr_ski*), expressed on a 1 to 5 scale, R&D workers in our sample are - on average - not very prepared to cope with "research exploitation" issues. They are quite able of

finding possible applications for their ideas, but not adequately skilled to concretize them through the support of business plans and market analysis.

Variable	Obs	Mean	Std. Dev.
r_ski_bplan	157	1.917197	1.006146
r_ski_eco	163	1.889571	1.071552
r_ski_impcom	156	3.307692	1.317943
r_ski_man	162	1.54321	.812165
r_ski_tplan	147	2.210884	1.250925

Tab. 3.4-1

Analyzing correlations we found that those who have business competencies and are able to foresee commercial applications of research findings are very satisfied when business success is obtained (ρ (zr_sod_com, zr_ski_impcom) = 0,44). They are conscious of the importance of linkages with academia (ρ (zr_suc_uni, zr_ski_imp) = 0,361), of the advantages coming from multidisciplinary teams (ρ (zr_suc_multi, zr_ski_imp) = 0,311) and from interaction with customers (ρ (zr_suc_cli, zr_ski_imp) = 0,262).

These evidences let us suppose that a self-reinforcing mechanism acts in motivating researchers who are business conscious to obtain visible and concrete results by exploiting their knowledge. They seem to be readier than others to face the speed of change in finding successful solutions to specific problems, eventually playing the role of "connectors" by asking contributions to external entities, such as universities or customers, or taking advantage from the multidisciplinary composition of internal teams.

HR managers should be aware of the importance of such subjects not only for their familiarity with business but also for their precious "linking capabilities" that appear fundamental in open systems of innovation inspired to the C&D paradigm.

3.5 Training methods and objectives

Since skills are related to education and training, we first tried to focus on different training characteristics (internal courses, external seminars, tutoring), and then we considered the personal goals of researchers who carried out these activities in order to find links.

Correlations among variables suggest that:

- continuous education increases the personal interest and satisfaction to publish (ρ (zr_sod_pub, za_for_corsiest) = 0,439) and has positive effects on publishing productivity (ρ (zr_pub_tot, za_for_corsiest) = 0,3);
- firms interested in publishing promote educational programs (ρ (zr_int_pubaz, za_for_corsint) = 0,433);
- training is often seen like a benefit and acts as an incentive (ρ (zr_ok_inc, za_for_corsint) = 0,481)
- training stimulates the sense of belonging to the firm, especially when carried out through tutoring (ρ (zr_ok_sensoap, zr_for_tut) = 0,213);
- internal courses increase the frequency of remote contacts among colleagues of the same group (ρ (zl_rem_team, zr_for_corsint) = 0,401);
- tutoring is fundamental in firms where teamwork is a key of strength (ρ (za_sw_team, zr_for_tut) = 0,397) or where relationships with suppliers are strategic (ρ (za_col_forn, za_for_tut) = 0,323).

We infer that, especially for firms interested in publishing, continuous training is a valid strategy to motivate personnel. It is seen as a sort of a gift, with wide positive effects on corporate climate, and a way to reinforce interpersonal relationships. In particular, when carried on in the form of tutoring, it promotes trust among colleagues acting as invisible "internal glue".

HR managers should then not miss this point but consider it like a sort of long term investment to accumulate knowledge, which is useful for coaching too.

Analysing the personal goals of training we see:

- training is useful to enlarge scientific knowledge rather than economic competences for those who consider publishing opportunity and education as key factors of the success of firms (ρ (zr_suc_pub, zr_forob_csci) = 0,225);
- researchers interested in the managerial career see training as a stepping stone for acquiring the managerial skills they need (ρ (zr_int_carman, zr_forob_cman) = 0,447);
- an implicit interest for entrepreneurship underlies the ambition for a managerial career, which is considered the final goal of training (ρ (zr_int_espimp, zr_forob_car) = 0,31).

We here observe the two different profiles of researcher as ideally defined in common dual ladder career system: those who are purely interested in scientific growth and those who plan a managerial career and drive their learning opportunities towards this objective.

3.6 Incentive system

We briefly tried to better understand which are the best incentives that should be offered to R&D workers. The correlation matrix suggests that:

- incentive mechanisms are still mainly centered on monetary benefits and career advancements (ρ (za_prem_mon, za_incent) = 0,45), that are preferred by researchers (ρ (zr_ok_premi, za_prem_mon) = 0,416);
- firms where career advancements are counterparts for results show lower defection rates caused by unsatisfying salary (ρ (zr_exit_stip, za_prem_car) = -0,154)
- firms giving learning opportunities are the best nests for innovative ideas (ρ (zr_ok_inc, za_prem_for) = 0,254) > (ρ (zr_ok_inc, za_prem_*)
- a well accepted incentive structure has to be supported by an appropriate system for evaluating single researcher's performances (ρ (za_valsing, za_incent) = 0,417).

Money and power have been confirmed as the most desired rewards: they are usually linked and, when correctly offered, prevent the most exigent R&D workers to abandon the firm. However they are not always the best methods to stimulate innovative ideas (learning opportunities are probably better) and need to be combined with rigorous and efficient methods to evaluate results. Performance evaluation systems are in general well accepted by researchers (ρ (zr_ok_valutaz, za_valsing) = 0,327) but usually juniors are a bit less aware of their functioning than seniors (ρ (zr_anz_rd, za_valsing) = 0,29). Transparent rules, clear goals and well defined parameters of evaluation may smooth this discrepancy.

3.7 Planning activity

In our survey we asked researchers to comment on how they feel the presence of planning, and how this effects their work. Planning might be a difficult task for the management of an R&D lab, since research and innovation are usually activities with objectives and results that are not easy to be determined from the start. In an open innovation environment, in particular, planning has to be dynamic and ready to adapt to emerging opportunities and obstacles.

The analysis of correlations suggests that:

- when researchers acknowledge the presence of planning, they also recognize a strong leadership (ρ (za_sw_leader, za_pianificaz) = 0,447);
- there is a positive correlation between perceived technological excellence and acknowledgement of presence of planning practices (ρ (za_sw_eccell, za_pianificaz) = 0,356);
- planning allows the creation of paths for personal growth (ρ (zr_ok_cresc_ind, za_pianificaz) = 0,333) and improves the perception of the reward system (ρ (zr_ok_premi, za_pianificaz) = 0,33), included salary satisfaction (ρ (zr_ok_retrib, za_pianificaz) = 0,286);
- when planning is implemented, top management reputation, competence and reliability are important for satisfaction (ρ (r_sod_topqual, za_pianificaz) = 0,211);
- planning reduces brain drain caused by the search for professional growth (ρ (zr_exit_prof, za_pianificaz) = - 0,177), and stressing conflicts (ρ (zl_stress_conf, za_pianificaz) = -0,187);
- when tasks are well planned researchers are less willing to go abroad for middle-long periods (ρ (zr_trasf_l, za_pianificaz) = -0,225);
- researchers in our sample are however not likely to recognize that explicit planning is a key factor of success for the firm (ρ (zr_suc_obesp, za_pianificaz) = -0,209);
- improving goal clearness and roles definition doesn't increase motivation in firms where planning is an established routine (ρ (zr_mot_defcomp, za_pianificaz) = -0,233), ρ (zr_mot_obchiari, za_pianificaz) = -0,233).

Synthesizing these evidences, we argue that task planning and explicit goal definition are considered by R&D workers as important practices. The fact that they are usually implemented in leading firms presenting a high number of strength factors reinforces this hypothesis. Planning is a hard work and should be carried out by competent and trusted managers. It can be useful to prevent abandons since it gives researchers the opportunity to follow clear paths of professional and personal growth.

4. Factor analyses

The results from our survey are difficult to observe only through a correlation analysis. We have more than 180 variables and each single variable contributes a bit to the puzzle, and helps us define the characteristics of the individual researcher and his/her team and company. Through factor analysis we are therefore seeking to better isolate key characteristics and common traits of researchers in our sample, observing common dynamics in answers across various questions. To perform factor analysis we first manually grouped variables referred to the same argument and then we performed three different analysis on these groupings in order to single out relevant factors. In this section we describe the results from factor analyses specifically carried out to look for the main sources of motivation (4.1), satisfaction (4.2) and firm success (4.3), as perceived by R&D workers. Factors have been identified through the interpretation of the elementary variables aggregations.

4.1 R&D professionals' motivation

We performed a factor analysis on zr_mot* variables, related to aspects that we considered relevant for the motivation of R&D workers. We asked them to rate on a 1 (min) to 5 (max) scale 11 items: technicians' involvement in decision making (r_mot_coinv), collaboration with colleagues (r_mot_collab), task definition and job division (r_mot_defcomp), training programs (r_mot_form), engagement acknowledgement (r_mot_impegno), information circulation (r_mot_info), skilled leaders (r_mot_leadcomp), clear goals (r_mot_obchiari), efficient responsibility system (r_mot_resp), lab member cohesion (r_mot_spiritlab), team spirit (r_mot_spiritteam).

Table 4.1-1 (see Appendix) shows the numeric results of the factor analysis, which has been performed with eigenvalues equal to 0.

Only 5 factors were retained. We tried to offer an interpretation of the heaviest components in order to discover the synthetic concepts underlying each factor, obtaining the following results:

1) Team spirit = f (*Collaboration with colleagues, Skilled leaders, Lab and team members cohesion*);
2) Defined objectives and roles = f (*Clear goals,*

Tasks and roles definition, Responsibilisation);

3) Trust in acknowledged valid people = f (*Involvement in decision making, Engagement acknowledgement, Efficient responsibility system)*;
4) Focus on professional growth of the researcher = f (*Training programs, Information circulation, Engagement acknowledgement*);
5) Collaborative environment = f (*Information circulation, Collaboration among colleagues, Skilled leaders*).

These aggregations suggest that:

- team spirit is fundamental in motivating researchers and increasing their productivity; it needs reciprocal trust among prepared people and circulation of relevant information;
- collaborative work environments motivate people;
- the most motivated researchers are those who are given trust through responsibility of some business and involvement in decisions and those for which firm take care of personal growth offering training programs;
- engagement promotion and acknowledgement are important motivation tools;
- clear roles and defined goals are fundamental in motivating researchers.

These findings lead to some preliminary implications. R&D managers should pay attention to coaching, stimulating strong relationships among colleagues and creating collaborative environments where professional growth is stimulated and talents are trusted and empowered. Moreover, they should let information to flow freely and guarantee adequate levels of transparency and clearness about single tasks' attribution and goals' definition.

4.2 R&D professionals' satisfaction factors

A second factor analysis was performed to identify the most relevant sources of satisfaction as suggested by R&D workers by rating them from 1 (min) to 5 (max). The set of variables taken into account refers to the zr_sod* group, composed by 9 elements: patenting opportunity (r_sod_brev), collaborative team (r_sod_climateam), good work environment (r_sod_climaz), results as source business success (r_sod_com), professional growth opportunity (r_sod_cresc), publishing opportunity (r_sod_pub), good external relationships (r_sod_rapest), good team leader (r_sod_tlq), top management quality (r_sod_topqual). As before, values were standardized and variables take the prefix "z-".

As shown in Table 4.2-1 (see Appendix), 5 relevant factors were retained; reduction was done with eigenvalues equal to 0. These factors can be defined as:

1) Good work environment populated with reliable people = f (*Collaborative team, Pleasant firm atmosphere, Good team leader, Top management quality*);
2) Institutional external acknowledgements of the work done (popularity) = f (*Opportunity to patent and publishing, Scarce relevance of work environment*);
3) Lone-wolf "arrogance" = f (*Bad external relationships, Poor top management skills, Sense of personal growth, Business successful results*);
4) Market appreciation of research results = f (*Good external relationships, Commercial success, Scarce relevance of work environment*);
5) Professional growth opportunity (unique most relevant variable).

It seems that:

- in companies with pleasant work environment researchers satisfaction is higher, greater if leaders and managers are cordial and competent;
- researchers are not so much looking for internal but external esteem through "institutional" (such as patents and publications) or market acknowledgements (result commercialization);
- commercial success increases self-confidence in R&D workers and may also be a sort of personal revenge for their commitment, which is not always adequately valued by top managers;
- professional growth opportunities are important factors of personnel satisfaction.

R&D managers are then invited to limit possible sources of stress and conflict and promote a relaxing untroubled internal atmosphere, where researchers can feel at home, conscious that the company is in good hands. In order to increase satisfaction they should also consider the opportunity to make research findings available outside the boundaries of the firm through publishing, fix clear rules on results' patenting, support researchers who pay attention to market dynamics from the earlier stages of the innovative processes, give them chances to grow and, obviously, monitor constantly personnel satisfaction.

4.3 R&D success factors

We finally investigated R&D success factors as seen by researchers, whose sentiments were synthesized in 17 variables (zr_suc*) representing possible sources of success and valued on a 1 (min) to 5 (max) scale. They are: autonomy and freedom to carry out the job (r_suc_auto), relationships with customers (r_suc_cli), efficient communication (r_suc_com), skilled project leaders (r_suc_complead), skilled technicians (r_suc_comptec), good conflict solving ability (r_suc_conf), cooperation and reciprocal support (r_suc_coop), paths of professional or managerial growth (r_suc_cresc), trust, respect and reliability among colleagues (r_suc_fidu), training programs (r_suc_for), interesting and challenging job for R&D technicians (r_suc_lavint), multidisciplinary activities (r_suc_multi), explicit goals (r_suc_obesp), publishing opportunity for researchers (r_suc_pub), links with universities (r_suc_uni), good evaluation systems and engagement

acknowledgement (r_suc_valut), job rotation (r_suc_varmans). Standardized values were put into factor analysis, which retained 9 principal factors defined by eigenvalues > 0 (see Tab. 4.3-1).

These 9 success keys can be read as:

1) Adaptability and permeability (Open Model) = f (*Job rotation, Links with universities, Publications, Multidisciplinary teams, Growth sense, Continuous training, Cooperation, Interaction with customers*);
2) Presence of stimuli to react = f (*Multidisciplinary groups, Links with universities, Autonomy, Interesting and stimulating job, Lack of explicit goals, Conflicts, Insufficient confidence*);
3) Team play = f (*Cooperation, Reciprocal support, Efficient communications*);
4) Focus on specific goals, with constant control and supervision performed by project leader = f (*Efficient evaluation system, Engagement acknowledgement, Qualified project leader, Specific projects*);
5) Clear mission + Free methods (only results matter) = f (*Explicit goals, Autonomy, Trust, Lack of relationships with customers, Lack of publications*);
6) R&D workers' empowerment and burdening = f (*Interesting and stimulating job for technicians, Autonomy, Lack of valuation*);
7) Qualified personnel = f (*Training opportunity, Skilled technicians, No job rotation*);
8) Reciprocal trust = f (*Confidence, Respect, Reliability among colleagues*);
9) Freedom of execution (unique most relevant variable).

According to these observations it turns out that successful firms:

- react to endogenous or exogenous stimuli adopting a R&D model open to external inputs and ready to adapt easily to the change; this model seems to lead back to the Connect & Develop paradigm;
- stimulate reciprocal trust among colleagues in order to favor team play, which is useful to face innovation challenges;
- have highly qualified and burdened personnel
- know that autonomy related to technicians' empowerment need a mission clearly defined by explicit goals; it is important to achieve them but not define how to;
- put the task of focusing on single objectives into the hands of project leader, who is capable to coordinate and assess colleagues, who trust and appreciate him .

Therefore it seems necessary to arrange R&D opening mechanisms by encouraging internal and external communication, team work and external collaboration, as well as to promote stronger relationships with the Scientific Community. It is also important to create the right environment to allow researchers cultivate interpersonal relationships. Nevertheless, it is fundamental to guarantee highly selective standards in the hiring process and schedule continuous training for researchers to maintain high their qualification. Finally, R&D managers are suggested to fix goals as precise and clear as possible, giving researchers the opportunity to choose how to achieve the result and charging qualified project leaders (focused on specific scopes) with the task of supervising and controlling in order to appreciate researchers' commitment and liability.

8. Conclusions

We tried to "look through the eyes" of a group of industrial R&D workers in order to obtain some early findings on the climate change we suspect is occurring in the labs. We investigated perceptions, feelings and behaviours of 330 researchers to extract evidences that may represent new trends or practices related in some way to the emerging paradigms of "Open Innovation" and "Connect & Develop". Some first results have been hypothesized and described in this paper. However, this first glance is based on the perceptions of a convenience sample that we drew from a selected number of industrial partners. Such findings are not to be generalized, they do not represent the characteristics of Italian industrial R&D but they rather give us good starting hypothesis for our analysis, as we collect a larger amount of data. In our effort to increase the size of the sample, by interviewing a higher number of industrial R&D workers, we seek to have findings that could be generalized to the entire national industrial R&D system.

Our next step is to create, through factor and cluster analysis a set of synthetic profiles through the aggregation of the single variables. We believe that the survey that we have designed is able to answer a variety of different research hypotheses and in our next works we will narrow them down to the key dimensions for the open innovation framework. Also, our model is able to provide HR managers a valid support for a climate analysis, and can be used as a basis for a SWOT analysis as well.

With more data and a better analytical framework we will be able to tune our benchmarking system and then offer both firms and single researchers an incentive in participating in our study.

The next step is to transform this first "trend analysis" of bottom-up signals in a more sophisticated and reliable one, eventually integrated with top-down perceptions, to better identify also firm-specific and causality effects between strategic and organizational choices and impacts on the climate. The final aim is to verify the consistency of the findings emerging from practice with the organizational theories discussed in the literature.

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APPENDIX

TABLE 4.1-1 – FACTOR ANALYSIS OF MOTIVATION GROWTH SOURCES

Factor analysis/correlation — Number of obs = 279
Method: principal factors — Retained factors = 5
Rotation: (unrotated) — Number of params = 45

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.01500	3.17009	0.8149	0.8149
Factor2	0.84491	0.34340	0.1715	0.9864
Factor3	0.50151	0.20066	0.1018	1.0882
Factor4	0.30085	0.25584	0.0611	1.1492
Factor5	0.04501	0.06346	0.0091	1.1584
Factor6	-0.01845	0.04334	-0.0037	1.1546
Factor7	-0.06179	0.03695	-0.0125	1.1421
Factor8	-0.09874	0.04948	-0.0200	1.1220
Factor9	-0.14822	0.07138	-0.0301	1.0920
Factor10	-0.21961	0.01385	-0.0446	1.0474
Factor11	-0.23345	.	-0.0474	1.0000

LR test: independent vs. saturated: chi2(55) = 1250.42 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Uniqueness
zr_mot_coinv	0.5731	0.1656	0.3984	0.0268	0.0077	0.4846
zr_mot_col~b	0.6788	-0.2679	-0.0278	-0.1535	0.0858	0.4357
zr_mot_def~p	0.6008	0.3614	-0.2444	-0.1670	-0.0417	0.4190
zr_mot_form	0.3854	0.1972	-0.1735	0.3138	0.0322	0.6829
zr_mot_imp~o	0.4556	0.1050	0.3367	0.1778	-0.0877	0.6288
zr_mot_info	0.5010	0.1760	-0.0878	0.2369	0.1116	0.6418
zr_mot_lea~p	0.6353	-0.0375	0.0730	-0.1524	0.0601	0.5628
zr_mot_obc~i	0.4865	0.3750	-0.2553	-0.0629	-0.0652	0.5493
zr_mot_resp	0.5980	0.2436	0.2046	-0.1670	0.0191	0.5130
zr_mot_spi~b	0.7737	-0.4212	-0.1142	0.0517	-0.0304	0.2073
zr_mot_spi~m	0.8131	-0.3942	-0.0755	0.0687	-0.0743	0.1676

TABLE 4.2-1 – FACTOR ANALYSIS OF SATISFACTION SOURCES

Factor analysis/correlation — Number of obs = 278
Method: principal factors — Retained factors = 5
Rotation: (unrotated) — Number of params = 35

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.24155	2.13756	0.7831	0.7831
Factor2	1.10399	0.83478	0.2667	1.0498
Factor3	0.26920	0.12897	0.0650	1.1148
Factor4	0.14023	0.09367	0.0339	1.1487
Factor5	0.04656	0.13073	0.0112	1.1599
Factor6	-0.08416	0.05737	-0.0203	1.1396
Factor7	-0.14154	0.05571	-0.0342	1.1054
Factor8	-0.19725	0.04179	-0.0476	1.0577
Factor9	-0.23904	.	-0.0577	1.0000

LR test: independent vs. saturated: chi2(36) = 970.88 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Uniqueness
zr_sod_brev	0.4352	0.6588	-0.0057	-0.0459	-0.0046	0.3744
zr_sod_cli~m	0.7595	-0.2609	0.1563	-0.1558	-0.0355	0.3051
zr_sod_cli~z	0.7507	-0.3256	0.0638	-0.1469	-0.0317	0.3038
zr_sod_com	0.5187	0.0937	0.2255	0.1933	0.0392	0.6324
zr_sod_cresc	0.4502	0.1099	0.1625	-0.0097	0.1539	0.7351
zr_sod_pub	0.3814	0.6514	-0.0921	-0.1009	-0.0320	0.4106
zr_sod_rap~t	0.5435	0.0489	0.1074	0.1795	-0.1253	0.6428
zr_sod_tlq	0.7224	-0.1798	-0.2529	0.0258	0.0462	0.3790
zr_sod_top~l	0.6908	-0.1264	-0.2818	0.1086	0.0146	0.4153

TABLE 4.3-1– FACTOR ANALYSIS OF FIRM SUCCESS KEYS

Factor analysis/correlation — Number of obs = 281
Method: principal factors — Retained factors = 9
Rotation: (unrotated) — Number of params = 117

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.84309	3.56058	0.6855	0.6855
Factor2	1.28251	0.46704	0.1815	0.8671
Factor3	0.81547	0.31199	0.1154	0.9825
Factor4	0.50347	0.11947	0.0713	1.0538
Factor5	0.38400	0.10625	0.0544	1.1081
Factor6	0.27775	0.12500	0.0393	1.1475
Factor7	0.15275	0.00520	0.0216	1.1691
Factor8	0.14755	0.12712	0.0209	1.1900
Factor9	0.02044	0.08082	0.0029	1.1929
Factor10	-0.06039	0.04345	-0.0085	1.1843
Factor11	-0.10383	0.02029	-0.0147	1.1696
Factor12	-0.12413	0.03882	-0.0176	1.1520
Factor13	-0.16295	0.01851	-0.0231	1.1290
Factor14	-0.18146	0.00694	-0.0257	1.1033
Factor15	-0.18840	0.05120	-0.0267	1.0766
Factor16	-0.23960	0.06210	-0.0339	1.0427
Factor17	-0.30170	.	-0.0427	1.0000

LR test: independent vs. saturated: chi2(136) = 1625.31 Prob>chi2 = 0.0000

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
zr_suc_auto	0.5748	-0.0708	-0.1850	0.1060	-0.0296	0.0968	0.2049
zr_suc_cli	0.3908	-0.3569	0.1086	-0.0620	0.1975	-0.0865	0.0081
zr_suc_com	0.5969	0.1842	-0.1144	-0.1484	-0.1339	0.0644	-0.0553
zr_suc_com~d	0.4836	0.2220	0.4962	-0.1237	-0.0278	0.0084	0.0957
zr_suc_com~c	0.4586	0.1583	0.5087	-0.0746	-0.1108	-0.0240	0.0949
zr_suc_conf	0.4484	0.2635	0.0137	0.1801	0.1515	0.2347	-0.0930
zr_suc_coop	0.6060	0.3790	-0.1279	-0.2608	0.1383	-0.1291	-0.0572
zr_suc_cresc	0.6198	-0.0482	0.0078	0.0386	-0.3393	-0.0670	-0.0784
zr_suc_fidu	0.6245	0.3383	-0.3067	-0.2239	0.1046	-0.1071	0.0271
zr_suc_for	0.6769	-0.2699	-0.0448	-0.0037	-0.0552	-0.0058	-0.1432
zr_suc_lav~t	0.4507	0.1464	-0.0880	0.3221	0.1271	-0.1513	0.0753
zr_suc_multi	0.5734	-0.3527	-0.1647	-0.0751	0.0951	0.1533	0.1618
zr_suc_obesp	0.4268	0.2528	0.0950	0.1086	0.0696	0.2873	-0.0852
zr_suc_pub	0.5668	-0.4248	0.0670	0.0877	-0.0464	-0.0305	-0.0526
zr_suc_uni	0.5476	-0.4372	0.1805	-0.0638	0.2104	-0.0451	-0.0835
zr_suc_valut	0.4210	0.2248	0.0493	0.4001	0.0253	-0.1894	-0.0108
zr_suc_var~s	0.4963	-0.0853	-0.2352	0.0201	-0.2547	0.0230	0.0344

Variable	Factor8	Factor9	Uniqueness
zr_suc_auto	-0.1355	0.0056	0.5485
zr_suc_cli	0.2380	-0.0060	0.6010
zr_suc_com	0.0504	-0.0905	0.5387
zr_suc_com~d	0.0100	-0.0332	0.4441
zr_suc_com~c	-0.0361	0.0326	0.4761
zr_suc_conf	0.0022	0.0510	0.6076
zr_suc_coop	-0.0238	0.0447	0.3631
zr_suc_cresc	0.0482	0.0370	0.4825
zr_suc_fidu	-0.0483	-0.0001	0.3259
zr_suc_for	-0.0830	-0.0287	0.4356
zr_suc_lav~t	-0.0196	-0.0386	0.6173
zr_suc_multi	0.0763	0.0073	0.4494
zr_suc_obesp	0.0449	-0.0180	0.6361
zr_suc_pub	-0.1498	-0.0049	0.4578
zr_suc_uni	-0.0540	0.0133	0.4160
zr_suc_valut	0.0744	0.0009	0.5676
zr_suc_var~s	0.1318	0.0338	0.6056