Managing between science and industry

An historical analysis of the Philips Research and Development Department's management

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Abstract

Purpose – This paper seeks to deal with the history of Research and Development (R&D) management. It takes the history of the R&D Department of the Royal Philips Electronics of The Netherlands as an example to unravel the dynamics behind industrial R&D management.

Design/methodology/approach – This paper is based upon historical and theoretical studies on industrial R&D institutions and research cultures.

Findings – The paper proposes that the directors of the Philips R&D Department continually shaped and reshaped the organization in order to retain researchers with creative ideas, and to stimulate innovativeness. The R&D-management was the outcome of a search process that comprehended a mixture of scientific and industrial (management) skills, knowledge and expertise, which together shaped an industrial research culture. One of the most difficult questions for the research managers was to find a balance between the professional status and motives of individual researchers on the one hand and the Philips company production strategy on the other. Over the years, the research leaders stimulated individual creativity in their own way, taking specific business and economic circumstances into account. They operated during different historical periods that reflect their management ideas.

Originality/value – Nowadays, the Philips research takes place at the High Tech Campus. Its philosophy is based upon Chesbrough's open innovation paradigm. In the discussion of this paper, it is argued that the history of industrial research teaches that the success of this organization, as in the past, will depend upon the management's ability to find a balance between scientific activities and industrial production.

Keywords Research and development, Culture, History, Innovation, The Netherlands

Paper type Research paper

1. Introduction

In 2002, the management of General Electric (GE) showed the world its commitment to Research and Development (R&D) investments. The world's largest company will increase its R&D budget and, more importantly, will enlarge its long-term research budget from 10 to 30 percent. In a reaction to the New York Times, Jefferey R. Immelt, GE's CEO and Scott C. Donnelly, one of GE's presidents for research, stated that GE wants to return to the mission of Charles P. Steinmetz, one of the founders of GE's Research Department in 1900: "Steinmetz did not want this lab to worry about next quarter's product. He wanted it to work on the next big idea, even as GE's businesses were refining the last one." (see Deutch, 2002) [1] The GE management's intention is a good example of the fact that corporate R&D managers think about a return to a century-old entrepreneurial strategy: to invest in long-term research activities.

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Moreover, GE's intention is not an exception. The Royal Philips Electronics of The Netherlands, recently, enlarged its Research Department in Eindhoven, The Netherlands (www.philips.nl/hightechcampus/index.html). This is interesting news for those who are interested in innovation and R&D management: big companies still belief in R&D investments.

Today's R&D managers refer a lot to history, and although industrial research takes place in ever changing organizational settings, as this paper will show, it seems as if each new generation of R&D leaders has to deal with the same kind of problems. It has been known for decades already that one of the bottlenecks in doing R&D in industry is the difficult relationship between research activities and the production of goods (Clark *et al.*, 1985; Mokyr, 1990; Mowery and Rosenberg, 1989; Nelson, 1996; Faulkner and Senker, 1995; Freeman and Soete, 1997). Nathan Rosenberg even talks about a paradoxical situation for industrial production firms who invest in scientific research (Rosenberg, 1990). Whereas the scientific activity is based on investigations with uncertain outcomes, industrial production firms try to reduce uncertainty beforehand as much as possible. To invest in uncertainty can also be seen, however, as an entrepreneurial act that brings creativity (i.e. R&D people) into the firm (Schumpeter, 1943). Importing creative people in the organization was only the first step. Next, good R&D leadership and management were about trying to "unlock" each employee's creativity and reward creative contributions [2]. In this process, the rise of the industrial research organization was a pivotal development.

Managing industrial research people, however, is and was not an easy job. Nowadays, there is much variation in how R&D departments deal with this problem. What is important to notice is that none of these departments has come up spontaneously. On the contrary, "the" R&D department as an institution has a long and interesting history. Can organizational scholars and R&D managers learn from the history of industrial R&D? Or do they have to learn the lesson of "how to manage research people" from scratch? In this paper, it is argued that the historical investigations can provide us with important lessons about R&D (workforce) management and leadership and about how individual people function within a research setting. The management of the creative processes in R&D settings is central in this paper.

The question is how the management of industrial companies – in this case Philips – over the years was able to hire and retain scientific people to contribute to the development of industrial products. In addition, when looking at the twentieth century, the question is whether the ideas of R&D-managers remained constant over the period or if they were subject to change. Because American examples occupy most of the debates in this field (Varma, 2000), this paper contributes to the literature by giving a European – Dutch – dimension to issues already raised in the American context.

In this paper, the history of the Philips R&D Department is taken as a major example for the argument that managing between science and industry is a difficult balancing act. The empirical part of this paper is based upon an in-dept historical study of the Philips R&D Department (Boersma, 2002; De Vries and Boersma, 2005[3]). The company examined is the Royal Philips Electronics Company, which was established as a mass-producer of light bulbs in The Netherlands in 1891 by Gerard Philips (see for details about the early history of Philips: Heerding, 1986, 1988). The Philips R&D Department started when, in the winter of 1914, Gerard and his

younger brother Anton decided to found a research organization as a separate part of their company in Eindhoven. They called this department in Dutch the "Natuurkundig Laboratorium" (in English: the Physics Research Laboratory and further abbreviated as Nat.Lab.). Nowadays, Philips research is known as one of the biggest industrial research institutes of the world. Philips has laboratories in five different countries (The Netherlands, England, Germany, China, and the USA) staffed by around 2,500 people. The research organization in Eindhoven, The Netherlands, houses a staff of almost 1,500 people.

In what follows, I will elaborate on the history of the Philips Nat.Lab.'s management. We will see that the R&D managers had to consider repeatedly (historically speaking) the question how to manage industrial researchers against the background of Philips as a production firm. The empirical part of this paper is about the actors, their roles, behavior, and their interactions. Its analytical focus is on individual differences in working and management styles. The paper will end with a short discussion on the benefit of the historical investigations for the today's management of science in industry. First, however, I will explore a theoretical discussion regarding the dynamics of management in industrial R&D organizations.

2. Managing an R&D setting – a theoretical investigation

The Philips Nat.Lab. history can be seen as part of a broader international development of industries that established in-house research departments (Hounshell, 1996). During the twentieth century, the function of the R&D department of big industrial companies became institutionalized. The research department was, so to speak, an outcome of "... the invention of the method of invention" (Whitehead, 1953, p. 96). The institutionalization of industrial research that followed, involved an intentional structuring of the research organization in the company. Recent historical studies show how industrial research departments went through a process of institutionalization during the first decades of the twentieth century (Dennis, 1987; Hounshell, 1996). These studies have set the historical paradigm for examining the history of corporate laboratories [4]. The approach, in this paper, takes the industrial research laboratory as an ideal type in the Weberian sense; singling out some major stages of historical developments that have taken place in industry since 1900 (Schroeder and Swedberg, 2002, p. 395). It highlights the history of a single modern institution of science and industry: the Philips Nat.Lab., putting its organizational development in a broader long-term perspective.

One of the lessons that can be deduced from the historical studies is that industrial research has been developed as a synthesis of organization and strategy articulated within the company (Carlson, 1991). Science and technology/industry were not linked until the late nineteenth century, and only after that period systemic organizational innovation became possible. This is to emphasize that, in Schumpeterian terms, entrepreneurs started to use scientific and industrial methods to innovate.[5] An important element in this entrepreneurial process was the evolution of an organized research culture in which variety and individuality, scientific investigations, and product development could prosper. It was not enough for companies simply to have a tradition of invention and innovation – they also needed a culture that permitted the coordination between people and resources that was necessary for research work (Wise, 1985, 1997; Reich, 1983, 1985). Over the years, industrial research laboratories went through different stages of

organizational-cultural development (Dennis, 1987; Varma, 2000) and the question is how we can study this evolving research culture.

Within the literature, organizational culture is often described as a pattern of shared assumptions produced by the top management (Deal and Kennedy, 1999). One of the assumptions in popular management literature concerning industrial R&D departments is that the director has to create unity in his or her organization with regard to the company goals. As a consequence, it often happens in practice that researchers who do not "fit" into the research culture are seen as a deviant and, therefore, as a threat for unity and consensus about research agendas. This idea has been criticized not only for practical reasons, but also because the description of culture as a set of shared assumptions established by a director is rather oversimplified. The organizational scholar Jo-Anne Martin argues that organizational culture is not (only) about unity but about diversity and fragmentation (Martin, 1992). In this perspective, subcultural consensus (there can be tensions in the organization but consensus within a specific research group) and a multiplicity of views (there can be no consensus among different actors) are possible. In addition, it has been said that, in order to understand the dynamics of organizational cultures, we need thorough historical investigations into the various narratives of organizations (Rowlinson and Procter, 1999). If we want to follow this idea, it is necessary to get a deeper (historical) understanding of the different motives and identities of the actors – in this paper, mainly the R&D managers – who were involved in the development of industrial research departments.

An industrial research department, or laboratory, is an organization in which experiments and knowledge production are central. Its administration provides the infrastructure to individual scientists and technicians for carrying out research work. Industrial researchers became rooted in organizational structures and inter-organizational networks that became more or less permanent (Kranakis, 1992). Karin Knorr Cetina even speaks about laboratories as total institutions, a term borrowed from Goffman, to explain that all the activities of the individual researchers are controlled and regulated by the authorities of the organization (Knorr Cetina, 1999, Chapter 2). The industrial research organization has one specific feature that distinguishes it from other laboratories (described by Karin Knorr Cetina as epistemic, knowledge creating, cultures): the potential tension between science and industry. The researchers of the industrial laboratories who were confronted with this tension became "industrial knowledge workers". The historian Margaret Graham states in this respect:

Research personnel have also been set apart by their professional status. Scientific researchers and research engineers have typically served two masters; while loyal to the companies that have employed them, they have also been influenced in their research priorities by the professionals that have judged the quality of their work and rewarded their efforts. (Graham, 1985, p. 182; Wise, 1997; Reich, 1983 and for a contemporal study: Zabusky and Barley, 1997).

In an industrial research department, the organizational decision-making process became highly dependent on the power of individual experts (see for this theme Alvesson, 1995). Most key-activities in these departments relied on specialized skills and knowledge of a range of role as scientists, engineers and laboratory assistants. The question is how such an organization could be governed. Historical studies [5] suggest that the management of industrial R&D people was never very strict. Following David Courpasson, I will argue that flexible, organic, decentralized

organizations, like industrial research departments, can be seen as "soft bureaucracies" in which centralization and entrepreneurial forms of governance are combined (Courpasson, 2000). That means that in these organizations strategies of "soft" control and coordination are preferred above a hierarchical and bureaucratic form of governance.

3. The management of the Philips Nat.Lab. in a historical perspective

Although big companies like Philips began with in-house research activities at the beginning of the twentieth century by establishing a research department, these companies still needed to invent how to manage the workforce of such departments and how to enable in-house research activities. In other words, as David Hounshell and John Smith argue in their detailed study of the Du Pont research departments:

> ... the modern industrial R&D laboratory did not emerge full blown from the minds of executives at such firms as GE, Du Pont, Eastman Kodak, and American Telephone and Telegraph. History of R&D ... provides a window through which to observe the changing relationships between science and corporate strategy as they were subject to both internal and external pressures (Hounshell and Smith, 1989, pp. 1-2).Rather than establishing a department with a given and well-known structural format, it was the organization of the research department itself that was subject for investigation.

The laboratory leaders' function not only was to build internal relationships, but also to relay information from the research department to the outside and vice versa (Knorr Cetina, 1999, p. 222). During its history, the research leaders of the Philips Nat.Lab. stimulated individual creativity in their own way, taking specific business and economic circumstances into account. They operated during three different (reconstructed) historical periods that reflect both the management ideas and the changes the Nat.Lab. played for the Philips company as a whole (De Vries, 1999). In the first period, 1914-1946 (in which Gilles Holst was the Director), the Nat.Lab. functioned as an integral part in the diversification of the company's product range. In these years, the lab went through a growth process, related to the diversification of the company. During the second period, 1946-1972 (in which Hendrik Casimir was the Director), the Nat.Lab. functioned as an separated entity among relatively autonomous product divisions (PDs), each of which has its own development lab(s). These divisions were the result of the formalization of the company structure. In the third period, 1972-1994 (in which Eduard Pannenborg (and later on Van Houten/Carrubba) was the Director), the Nat.Lab. gradually became more closely tuned to the needs of the PDs. A road towards mutual commitment was traveled in which formal agreements would play a much more important role than in the previous periods.

In what follows, the historical development of the Philips Nat.Lab. will be given. The distinctive features of the three different historical periods will be taken as a framework for analysis.

3.1 The leadership of Holst: managing new knowledge workers

The Philips brothers hired Gilles Holst to become their Research Director in 1914. Holst's idea about what an industrial laboratory's task had to be, becomes clear from a proposal in which he admitted to maintaining that:

> ... an industrial laboratory is a facility where problems relevant to the industry are investigated with the aid of scientific methods and instruments... whereas, for example,

in a university laboratory one can always think up a problem that can be solved with the aid of the available tools, in an industrial laboratory where the problems are given, one must always ensure that the necessary tools are available (Holst, quoted in Blanken, 1999, p. 189).Holst proved the business value of industrial research by carefully embedding his researchers into the Philips companies' structure as a whole (Boersma, 2003b). As soon as the Nat.Lab. employed scientists in a new role as industrial researchers, a new structure was created in which freedom and practical usefulness could be combined. As a Director, Holst tried to co-ordinate research and the accommodation of researchers in industrial settings by stimulating people to publish scientific articles in external journals and to participate in the international colloquia held at the Nat.Lab. This move was necessary for hiring scientists in an industrial environment, because he had to find a balance between the scientific ambitions of his professionals and the demands of the company that asked for production of (electronic) goods. In theory, these are two conflicting modes; in practice, Holst, as the manager, had to find the balance.

In the early decades of the twentieth century, it was exceptional for a scientist to accept a job in an industrial environment. Philips took on young, gifted scientists from Dutch universities and Holst's task was to "transform" these men (. . .) from academic researchers into industrial researchers. Philips removed the researchers from the academic world and Holst socialized them into the organizational culture in order to develop an awareness of the researcher's role in the product development processes. This was not a straightforward process, since individual researchers often claimed their individual freedom and expertise. This behavior caused tensions and power-games within the laboratory (Boersma, 2003a). The "merger" of industrial and academic cultures to attract researchers was a way of doing industrial research that had been encountered by companies that shaped the historical institutionalization process of "the" industrial laboratory.

Holst focussed on the roles and identities of scientists and engineers in his organization, but at the same time he tried to stimulate an academic culture in which individual scientists could prosper. That means that Holst had a dual management-agenda: he was crafting an organizational culture that was different from the main organization of Philips, but one that could be aligned with the organizational goals. He also formalized his organization in order to cope with its expansion and growing number of individual experts. During the growth of the organization, organizational change instigated by formatting "informal" research groups and organizing regular gatherings with agendas and protocols and participating in committees to exchange knowledge inside and outside the company. It was a structural way of re-acting to the growth of the research program. His idea was to organize the contacts within the Nat.Lab. as informally as possible. At the same time, he forced his researchers to think about their role as a servant of industrial production.

In the first decades of the twentieth century, the electrical industrial technology sector that had reached a high standard of product development. The complexity of the technology had consequences for the required level of knowledge. Holst, in his role as research manager and leader, was able to provide Philips with a source of up-to-date knowledge. In this period, the Nat.Lab.'s management started with a patent strategy that enabled Philips to profit from the scientific investigations. The focus, however, was still on the improvement and diversification of products such as light bulbs, (radio and X-ray) tubes and magnetic materials. It was only after Holst's retirement in 1946 that this strategy would change.

3.2 The leadership of Casimir: managing professional scientists

The years after the Second World War might be termed a period of transition, because the internal structure of the Philips company and the Nat.Lab. was subjected to change. The way in which the research activities were integrated into the company, changed in the post – war period (De Vries, 1999). In the period under Holst's directorate, the Nat.Lab. became isolated in the company. This was partly due to the way that Philips had re-shaped its company structure. Equally important, in a period of worldwide "trust" in the promising outcomes of free scientific research, the new research leaders of Philips expressed that they would establish an institute in which fundamental research would be given a chance. In the USA, Vannevar Bush's influential report Science – The Endless Frontier had promoted basic or pure (scientific) research (Bush, 1945). According to Bush, the Second World War had shown that science was the driving force behind technological developments. Although almost none of his concrete recommendations were realized, the rhetoric of the report had an impact both on politicians' and researchers' expectations of basic science (Dennis, 1997). The ideas and leadership-style of the new Nat.Lab. Director Hendrik Casimir, who was an internationally known physicist and who has worked in the 1920s with scientists such as Bohr, Pauli and Ehrenfest, seemed to fit perfectly well in this philosophy.

During this period, there was no project budgeting at the Nat.Lab. as Casimir was against this, for he was afraid that it would be an obstacle to research freedom that was necessary for "fundamental" research. Casimir developed a formal hierarchical structure within the laboratory comprising layers of managing directors, directors, official group leaders, scientists, assistants, and technicians. More than in the Holst period, the internal decision structure of the Nat.Lab. was formalized as a reaction to a growing diversity of research activities. At the same time, the Nat.Lab. Casimir saw it as his main task to stimulate individuals in their research work. The purpose was that this form of research, aimed at establishing a deeper understanding of natural phenomena, would open the way for new products in the company's portfolio. In the years 1950-1972, the Nat.Lab. directors, inspired by the idea to carry out theory-driven research, tried to make basic science as a core task for the Nat.Lab. researchers.

In a sense, the Philips Research Department became rather separated from the rest of the company (Blanken, 2002). This shift did not mean that the researchers operated in isolation from other scientific institutes. The opposite is true; Casimir stimulated his researchers to keep in touch with scientists all over the world (research is an international activity and duplication is useless, as he said). In doing so, he stimulated his researchers in their creativity, without the burden of too much bureaucracy.

To increase innovation, Casimir displayed an interest in the latest developments in the natural sciences, but not just for the sake of his academic status (Sarlemijn, 1984). In the Corporate Research Conferences (CRCs), Casimir always investigated if the new scientific theory or field could be absorbed into the Nat.Lab.'s research program. He also stimulated the exchange of researchers between the several Philips labs. Under Casimir, the Nat.Lab. population of scientists grew from 157 in 1946 to 388 in 1965, the assistants from 170 to 991 and the administrative personnel from 240 to 722. It is, in this period, the success of the Nat.Lab. became measured in terms of scientific articles published, technical reports that were produced and, most important, the amount of patents that were acquired.

This rapid growth and changing of the researchers' roles required creative management ideas. Although the researchers under Casimir worked in a formalized organizational structure, they had a lot of freedom in choosing their research projects. Allowing his researchers to participate in these professional activities not only shaped the individuals' identities, but also the laboratory benefited from these contacts, because, in this way, researchers were able to influence broader technological developments. Thus, a careful scanning of the latest scientific developments became a continuous issue on the CRC agendas under his leadership.

Interestingly, this vision led to proposed greater freedom for the researchers within the Nat.Lab.'s organization. It was Casimir's policy from the beginning to stimulate researchers in their creativity by adopting a liberal research culture. Unfortunately for Philips, it can be seen in the Philips history that at the same time the new research function often led to tensions between the Nat.Lab. and the PDs. The lack of mutual commitment led to a gab between laboratory research and factory production at Philips in the Casimir period. The Nat.Lab.'s management did not see it as a core task to carry out research activities into the practical problems raised by PD managers surrounding the existing products. This attitude would change in the next period. Forced by the circumstances, the Nat.Lab.'s management had to (re)think how to manage the research people.

3.3 The leadership of Pannenborg: managing industrial researchers

In 1972, Eduard Pannenborg succeeded Casimir as the research representative in the company's Board of Management. In the same year he gave a presentation to the Nat.Lab. management in which he explained his vision for research development within Philips (Pannenborg, 1972). He sketched a number of differences between the period 1946-1972 and the coming years. According to him, in his days, more than "in the time of the GE researchers Langmuir and Coolidge" a lot of scientific knowledge outside industries that should be "translated" by industrial research organizations for use within their companies. The knowledge developed in these research organizations, was more applied than in earlier times. However, Pannenborg was confronted with the deeply rooted academic strategy of his predecessor Casimir. Consequently, the lack of a mutual commitment between the Nat.Lab. researchers and the factory people became a serious problem.

There was a reason for Pannenborg to rethink the role of scientists in industry. When he became the research leader at Philips, a long period of economic growth had come to an end. It was no longer taken for granted that companies like Philips were willing to invest in expensive research departments. The Philips' top management asked for a return of investments. As a consequence, efforts in research activities with uncertain outcomes had to be limited. One of the major struggles for Pannenborg as a research leader was to find a balance in individual freedom at the research department and a commitment between PDs about the research agenda. Pannenborg defended the idea of a continued separate and independent research organization, even though he perceived that it was not the practice in other large comparable companies such as Bell AT&T and Siemens. At the same time, he did insist on a decreasing attention for the "technology push." Instead, he pleaded for an increasing attention among his researchers for "market pull" (Pannenborg, 1975). In this process, Pannenborg made his people aware of their role as industrial workers.

This new strategy asked for another attitude among his researchers. Instructed by the Philips Board of Management, the Nat.Lab. management introduced contract research together with a new way of financing research activities in 1989. From that time, the Nat.Lab. peoples had to approach the Philips factories to get contracts from them. In this way, the individual researchers were encouraged to think about a customer orientation. Later, in the 1990s, the management of the Nat.Lab. used the terms "key technologies" and "capability management". When Carrubba came in 1991 from Hewlett Packard to the Nat.Lab. as a successor of Van Houten (who had succeeded Pannenborg in 1992), he stated that the researchers of the Nat.Lab. should be the knowledge workers for the company. In line with this, he saw it as his main task to enhance the researchers' skills that are necessary to meet the company's demands. That meant that a number of key technologies and capabilities should be kept active, even though there were no possibilities for contract research related to these. An effective capability portfolio should ensure that for all projects adequate and state-of-the art knowledge is present in the research organization.

During the so-called operation Centurion, a company-wide re-organization, the Philips top-management further pushed the Nat.Lab. people into the direction indicated in the 1970s, when the influence of the Philips factories on the research programme started. When Carrubba called 1989-1993 a "period of transition" one in which the formal decision for contract research was transformed into practice. By 1993, a certain consolidation took place of the management-changes that the Nat.Lab. had experienced in the previous turbulent years. It seemed that the research people had created a new task profile in the company: they became contract-workers within their own company.

4. Discussion and conclusion

As the former Nat.Lab. Director Hendrik Casimir has argued, industrial innovation takes a nonlinear path and R&D activities are not carried out in a vacuum (Casimir, 1983). That is not to say, however, that managers cannot learn from the history of the Nat.Lab. The story above demonstrates how the Nat.Lab. research directors in each historical period stimulated the work force to come up with creative ideas in an open research culture even within a bureaucratic system. It also indicates how the management of a specific industrial research laboratory – the Nat.Lab. – over the years shaped and reshaped the organization in order to cope with the tension between scientific activities and industrial production. The long-term perspective of this paper allows a further organizational management analysis. Of course, one can argue that the management solutions to the problem of how to find a balance between science and industry described above is typical and unique for specific historical periods. After all, during each period the company and its market had specific features. It is also apparent, however, that certain ideas remained constant over this period and were found at other industrial research departments. This indicates that although the management of the Nat.Lab. organization was not a linear process, but rather the outcome of the interaction of several individuals, groups and techno-scientific networks, one can see a rationale behind the "principle of (industrial) research" (Weber in Schroeder and Swedberg, 2002). It was the "invention of the method of invention" that provided the individual researcher with a reliable and institutionalized industrial research organization. With the rise of industrial research, as this paper illustrates,

scientific activities became deeply influenced by business economic factors such as the production of goods.

It was important for the research directors to tune research work to production work at Philips. The most important task for the Nat.Lab. managers, over the years, was to find a balance between the professional status of the individual researcher on the one hand and the company's strategy on the other. In this regard, the professional researchers developed their research skills and knowledge in response to personal and company needs as well as their networks that transcended the laboratory's boundaries. The Nat.Lab. leader's task was to stimulate an open research culture in which researchers could serve the interests of the company while conducting scientific research.

The directors of the Nat.Lab. built strategic visions for creating unity and, at the same time, giving the individual researchers a feeling of freedom to do scientific work. It is true that the personal interests, decisions, education, motives, and characters in organizational processes could be different. Therefore, the Nat.Lab. managers paid special attention to differences between the various actors working in their organization. In an industrial research setting like the Nat.Lab., (local) entrepreneurs, research directors, key individual scientists, engineers, and assistants might have had different goals, but together they shaped the organization, its structure and its researchers' identities. During each period, the Nat.Lab. manager had to deal with different problems/challenges, opportunities strongly influenced by the potential tension between scientific research on the one hand and production of goods on the other.

It is most likely that industrial research organizations will evolve into networked and cross-organizational institutions. Roli Varma, in her analysis of US industrial research cultures, predicts that in the future corporate laboratories will organize themselves in an open network with business mangers, customers, suppliers, R&D sponsors, university researchers and scientists working for other industrial and government laboratories (Varma, 2000, p. 413). It is striking in this respect, that today Philips no longer calls its own research organization Nat.Lab. Instead, it houses the research activities in Eindhoven at what is called the High Tech Campus, which is based upon Henry Chesbrough's idea of "open innovation" (Chesbrough, 2003). This means that Philips cooperates with other companies at the same campus in conducting research stimulating their own researchers to start up small-scale spin-off firms. The Philips research management makes this ideology explicit on its own web site stating that a "... one-firm research solution is a thing of the past". In line with Chesbrough, it says that it is much smarter to share knowledge and experience as well as expensive research facilities with others (www.hightechcampus.nl).

The open innovation process, however, is not without problems – it is difficult to gear all the activities, motives and strategies of the various actors to one another. At the moment, Philips is in a process of re-inventing and re-shaping its research process. Further, empirical research into the open innovation paradigm is necessary in order to understand how it will provide guidelines for the R&D management process. History teaches us an important lesson here: the quality of industrial research, also if it takes place in an open, networked research setting, will depend on the management's ability to find a balance between scientific activities and industrial production.

Notes

1. I would like to thank an anonymous reviewer of one of my earlier articles for this reference.
2. I am grateful to one of the anonymous reviewers of this paper for this remark.

3. In these two books the authors – one of which is the author of this paper – refer extensively to archival sources.
4. Significant contributors have been historians Bernard Carlson, who studied the pre-history of GE's R&D laboratory (Carlson, 1991), Margaret Graham, who wrote about research at RCA (Graham, 1986), David Hounshell and John Smith, who studied the history of Du Pont's R&D activities (Hounshell and Smith, 1989), Leonard Reich, who wrote a thesis on Bell's R&D system and a major comparative study of the labs at GE and Bell (Reich, 1985), and George Wise, who wrote the biography of Willis Whitney, the GE's laboratory's first Director (Wise, 1985).
5. Of course, literature also shows the importance of others sources, such as the knowledge of end-users, in the whole process of innovation (Von Hippel, 1994). This, however, is outside the scope of this paper that focuses on the organizational development of an industrial research department.

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