3th International Conference on Public Communication of Science and Technology (PCST), Montreal,Canada,10-13 April,1994

PROLETARIANIZATION OF SCIENTISTS?

Roli Varma
Department of Science and Technology Studies
Renesselear Polytechnic Institute
Troy, NY, USA

Abstract

Social scientists working in the Marxist tradition have tried to locate the position of professionals in the class structure under condition of monopoly capitalism. While traditional Marxists treat professionals as a working class, neo-Marxists regard them as a new class. In a study of 47 industrial scientists, it was found that they do not carry out research by themselves; they do it with other scientists under managerial supervision and control. Still, they distinguish themselves from other workers on the grounds of possessing highly specialized knowledge, internal motivation, creativity, autonomy, and high salary. Interviews with scientists indicated that internal differentiations among themselves is an obstacle to any unified class consciousness.

Introduction

Social scientists working in the Marxist tradition have argued for the *proletarianization of the professional* (Gorz 1967; Braverman 1974; Larson 1977; Derber 1982; McKinlay 1982).[1] Marxist scholars place professionals in the capitalist political economy and define their class in terms of capitalist relations of production. They view professionals as being part of the working class proletariat since they do not own means of production and work for others. In Braverman's words: (1974, p. 378 & 403) "the formal definition of the working class is that class which, possessing nothing but its power to labor, sells that power to capital in return for its subsistence.'' The professional "like the working class possesses no

[1]. Proletarianization by Marxists is seen as a complex historical process which progressively produces the proletariat. Proletarianization of professionals is conceived as a shift towards dependent, salaried employment, in which the labor of professionals becomes subject to the authority and control of those serving the capitalist interests.

economic or occupational independence, is employed by capital and its offshoots, possesses no access to the labor process or the means of production outside that employment and must renew his labor for capital incessantly in order to subsist.''

Some neo-Marxists disagree with traditional Marxists and instead argue that professionals are a third class. For instance, Ehrenreich and Ehrenreich (1977a, p. 13) have advanced the notion of the "Professional-Managerial class'' as consisting of "salaried mental workers who do not own the means of production and whose major function in the social division of labor is …the reproduction of capitalist culture and capitalist class relations.'' According to them, the professional-managerial class includes teachers, social workers, psychologists, entertainers, writers, lower and middle-level administrators, managers, lawyers, accountants, nurses, physicians, engineers, and other technical workers. Gouldner (1979) used the term the "New Class'' for the same occupations. He proposed that the members of the new class constitute a class because of the formal knowledge they gain from their higher education and on which they depend for their living in the market-place.

In this paper, we address the question whether capitalist development in the global economy is leading to a decline in the status of industrial scientists. To this end we interviewed 47 scientists of corporate research and development (R&D) laboratories on the question whether they are a new class, or a working class. Methodology and characteristics of subjects are given in the appendix. We find a partial support for the proletarianization of scientists hypothesis, as corporate R&D has been restructured since the eighties. We also see numerous shortcomings in the Marxian model as scientists do not consider themselves as a part of the working class. Our research adds some support to the neo-Marxists theory of scientists as a new class in relation to the working class. However, scientists continue to be divided along the lines of disciplines and specializations; and thus remain as an occupational group rather than members of a new class.

What Have Scientists Lost?

Scientists like any other working people are prone to experience all kinds of work-related tensions. What is new is how they are being affected by the changes in the organization of industrial R&D since the eighties. Earlier, R&D was viewed as a key to economic growth and social well-being, and a premium was placed on stability in funding. However, due to changes in the global economy effecting companies, growth in R&D expenditures has slowed down since the mid-eighties in constant dollars.[2] From 1979 to 1984, industrial R&D expenditures grew at annual rate of 7.4 percent in constant dollars compared with 3.0 percent during 1984-89. And by 1989, constant dollar expenditures actually declined to 1.3 percent. Estimates for 1991 indicate that industrial R&D expenditures were reduced to 0.9 percent in inflation adjusted dollars (NSF 1991, p. 143-144).

Decline in industrial R&D expenditures has coincided with corporate R&D restructuring. The *autonomous model*, which existed since World War II, has been replaced by the *linkage model* in many leading corporate R&D laboratories since the mid-eighties (Varma 1993). The new model involves reorganizing the laboratory to *directly link* research to business divisions (See Table 1). Earlier, corporate R&D laboratories enjoyed a large degree of autonomy from the business divisions of the company. Scientists proposed research projects related to the general goals of their company. Managers believed that scientists were professionals who needed to be left alone to make their own decisions without any pressures from non-technical people. Since the mid-eighties, many leading corporate R&D laboratories no longer enjoy the earlier autonomy from the rest of the company; now, they depend on contracts from different business divisions. Corporate R&D expenditures are no longer an outcome of a flat tax on sales/profits of the various business divisions of the company. Instead, scientists and managers have to get projects funded by business divisions. The proportion of funds generated by business divisions and by the company varies in different corporate R&D laboratories; however, many leading corporate R&D laboratories such as General Electric and Bell laboratories have changed their funding structure from one-third being generated by business divisions to almost two-thirds and one-half respectively. Since the funding for research is coming directly from business divisions of the companies, they support only what they consider to be important. Usually, they

---

2. Constant dollar is the term used to describe yearly dollar figures that have been adjusted by the 1982 GNP implicit price deflator to discount the changing levels of expenses due to inflation. Such deflated figures are then compared on a year-to-year basis relatively free of any bias introduced by the presence of inflation.

are interested in addressing specific questions for their immediate needs; they tend not to support the basic and long term research of scientists.

As corporate R&D laboratories are being reorganized, scientists are being severely affected, and perhaps are being proletarianized (Varma & Worthington 1993). Project selection is the most important R&D activity from the standpoint of corporate goals and scientists' careers. Scientists work on projects, and research in corporate R&D laboratories is conducted through projects. Under the autonomous model, most projects were generated by scientists themselves; only some were assigned by the management. It was rare that managers would specifically tell scientists what to do. If projects were assigned by managers, this would involve consultation or discussion with scientists. Management's job was to get scientists interested in particular areas. Scientists generated research projects which interested them the most from a technical stand point, but also fell within the general goals of their company. However, under the linkage model scientists have little to say

Table 1

Main Features of the Autonomous and Linkage Models

The autonomous model	The linkage model
Existed since World War II	Implemented in the mid-eighties
Corporate R&D enjoys autonomy from the rest of of the company	Corporate R&D depends on the rest of the company
Company's generic interests as a source of research	Customer's need as a source of research
Indirect link between research and business divisions	Direct link between research and business divisions
Strategies for R&D are well-established	Strategies for R&D are vague
Scientists persuade managers to support their research	Scientists persuade managers and buisiness divisions people to support their research
Stability of funds for research	Instability of funds for research

Funds generated as a result of a flat tax on the company's business divisions	Funds generated as a result of direct contracts from the company's business divisions
Money is not the focus of research	The focus of research is where the money is coming from
Emphasis on research	Emphasis on development
Emphasis on long-term research	Emphasis on short-term research

concerning what projects they will work on; instead, projects are being dictated purely by business interests. Scientists either have to look at the business divisions to find out what problems need to be solved, or they are informed by their managers on the work which needs to be done in the business divisions. This pattern is described in one scientist's words: "Earlier I selected my own projects. My manager did not come and tell me what to do. I had a lot of freedom… Now most of the projects are given to me. I only decide how to carry out those projects. I no longer develop my own research projects…''

Earlier, scientists had a lot more autonomy to select their research agenda. They figured out how their research interests coincided with the company's goals and interests, and generated ideas which were in close harmony with the laboratory's goals. They performed their research according to their own judgment, without any direct supervision from managers. Managers indirectly controlled scientists' work by evaluating the proposals. However, evaluation of projects was rather informal. They basically supported projects if they were convinced that there was a need for the proposed technical knowledge. With the linkage model in effect, R&D managers and business division managers are controlling research by allocating funds necessary for the research. Now it is funding which ultimately determines what projects are undertaken, how they can be achieved, and what projects will be discontinued. Managers, by using funding criteria, determine why certain types of research projects are encouraged or refused further support, whether scientists get requested technical assistance or equipment, and the time frame in which to finish the work. As one scientist said: "You have to have money for your research. No money, no research. This is the bottom line.''

Prior to the restructuring, scientists had to justify how their research would be valuable for the company. One problem scientists faced was that often it was difficult for them to specifically identify how their projects would be valuable for the company in the short run because the specific outcome of research is unknown, and they cannot identify the end result of their work before the work is completed. The other problem they faced was to greatly reduce the technical content of projects since the upper level of managers were not trained in scientists' disciplines. Trying to convince different layers of managers was a major undertaking for scientists because managers at the top level were often unable to understand particulars of a project. Generally, an immediate manager of scientists knows something about what scientists are doing, and the manager may be technically in a position to find loopholes in the projects. Managers above first-line managers have different expertise than scientists, and do not have the expertise to evaluate the scientists' work. With the changes in the funding system, scientists have to deal with outside managers as well as their own managers to get funds. Unlike R&D managers, business division managers seldom have a background in scientific or engineering disciplines. Instead, they have expertise in finance, business, accounting, budgeting, marketing, and so on. Consequently, they try to support projects in terms of output mode instead of scientific and technical details. Scientists are no longer able to debate the scientific contents of their research projects. As one scientist said: ''Business division managers are not technical people, and it is painful to convince them to fund a project.''

In the old days, many corporate R&D managers had long term perspectives and they supported the work that went beyond the immediate needs of business divisions. They emphasized the fast moving technologies of generic interest to the company. As a result, scientists were able to convince their managers to support basic, long-term projects. With the restructuring, scientists cannot get funding from their managers and managers in business divisions if their proposals are for basic long-term research. Corporate R&D managers are not excited about long-range scientific research because there is pressure on them to show immediate financial returns. Managers in business divisions who fund research are preoccupied with addressing the specific short-range problems for their immediate needs. They ''don't want to consider anything which will take more than a few months.''

Scientists must get their work funded from the business divisions. If they are unable to get funds for their projects, they will have to move to other projects. Scientists with inadequate funds will have to work with scientists with more funds. Such shifting of scientists from one project to another is often damaging to their careers. It shows that what they have accomplished so far to establish their careers is no longer relevant, and that they have to work on a project for which they have little expertise. Often, scientists have to terminate research which they have been working on for a number of years and switch to an area which has adequate funds.

Scientists are driven to have a lot of projects to raise a certain amount of funds. Often, such projects are different from each other in the sense that there is no underlying common theme. In other words, with the restructuring scientists have had to diversify themselves in many areas; this is counterproductive to their careers and to the quality of research. One scientist explained his projects situation: "At this point I have been forced to take two major and two minor projects. Two of these projects are barely related to each other. How can I do my best on these projects?"

Scientists, who mostly did research prior to the restructuring, now have to spend a significant amount of their time doing marketing for their projects. The funding process which came with the restructuring forces scientists to take the new role of salesperson in order to acquire funds from business divisions.

With the corporate restructuring, funds for research have been reduced. This means fewer technicians and less resources are being assigned to scientists than had been in the past. However, the number of projects being carried out in a corporate R&D laboratory continues to remain the same. It is seldom the case that when there are fewer people and less equipment to do the work, the workload of scientists decreases. As a result, scientists are often overwhelmed with things to do but do not have adequate resources. One scientist resented that: "Our lab has been reduced from fifty to thirty-seven. So I have to do everything."

The reward system has also changed with the restructuring. Now scientists are being recognized by managers if they have generated financial support for their projects as opposed to research results which was the case in prior years.

To summarize, we find a partial support for the Marxist theory of proletarianization of scientists in that their working situations are deteriorating with the restructuring of corporate R&D laboratories. Earlier, scientists enjoyed freedom to select and perform their research according to their own judgment, without direct managerial supervision. Managers indirectly controlled the scientists' work by evaluating projects along lines that fit with the company's goals. Now scientists' work is directly controlled by allocating the funds necessary for the research. Scientists have to propose their work to various managers and/or people in business divisions to get funded. These funds are ultimately determining what work scientists can do and how. Scientists do not exercise the authority that managers do. Scientists are reduced to proposing projects and determining how they will be conducted once managers have granted the funds. The right to allocate funds by managers does represent the power to advance the particular interests of the capitalist class, to use Marxist theorists' terminology.

Can we conclude from the declining status of industrial scientists that they are a part of the proletariat? Marxists regard scientists as working class proletarians because scientists like workers do not own the means of production, they work for wages, and they experience conflicts with the management representing the capitalist interests. We find that even though scientists are losing their privileged position in the industrial setting, they are far from withering away to join the working class. Below, we report the findings of interviews on the similarities and differences between scientists and other workers.

Scientists and Non-technical Workers

Scientists whom we interviewed attached more importance to the differences between scientists and non-technical workers than to the similarities between them. Scientists acknowledged that they, like other non-technical workers, work for the company, get a salary for their work, and report to a higher authority. Six scientists even said that the question is not how scientists view themselves, but how the management views scientists; because, for the management, everyone is a worker, doing different tasks. However, most scientists held on to a number of differences between them and non-technical workers, such as salary, education, expertise, motivation, and autonomy (See Table 2). They also did not regard their work as superior to that of non-technical workers. They believed that "all work is important and necessary." It should be noted that even when scientists claimed there is equal value to scientific and non-scientific works, they are unlikely to acknowledge otherwise; this is something that would show up in their behavior rather than in discussion. The general view of the scientists was: "I differ because I earn more money, I am technically qualified, there is more prestige attached to my job, and I have lots of freedom."

Table 2

How do Scientists Distinguish Themselves from Workers?

Factors Identified	**Scientists' Responses** (n = 47)
Advanced Degree	45
High income	42
Self-motivation to work	39
Autonomy	31
Creativity	16
No union needs	3

Forty-five out of forty-seven scientists distinguished themselves from non-technical workers on the basis of their advanced degree. Higher education and skill have been two of the main characteristics of professionals in general. Scientists engage on occupations which demand highly specialized knowledge and skill acquired by prolonged education that is certified by some professional society. Their knowledge is formalized into concepts, theories, abstractions, systematic explanations, rational reasoning and justification of the facts. What scientists are involved with cannot be done by people who do not have similar knowledge and training. Their education involves a system of beliefs which are considered scientific, such as cause and effect. Because of specialized education and training, scientists cannot be easily replaced; in principle, a non-technical worker can be replaced easily. In one scientist's words: "We are not task oriented. We are concept oriented. It comes from a different frame of thinking. If you put a scientist in a non-scientist position and vice versa, it will take the scientist less time to learn non-scientist's stuff than vice versa. But both would be unhappy."

Because of education, training, and experience, scientists are paid better than non-technical workers. Scientists do not have trade unions as non-technical workers do to negotiate their salary; still, scientists' pay is high. The average yearly income of scientists whom we interviewed was $70,000. Non-technical workers' income does not compare with such a high figure. It is therefore no surprise that forty-two scientists pointed to high income as a major dividing line between them and non-technical workers. In fact, three scientists even pointed out that they have no need for a trade union to negotiate salaries and other benefits.[3] Associations representing scientists perceive little conflict of interest between management and labor, often because their members are in both camps.

Talking about their work habits, thiry-nine scientists pointed out that they work for the company, but they also work for themselves. The motivation to work differs between scientists and non-technical workers because scientists feel that they gain much more intrinsic or ego satisfaction from their research. They view their work as more central than that of non-technical workers, but as more important than leisure. According to them, non-technical workers "do the job, make money, and go home.'' Scientists also do that, but they work towards "something other than paychecks.'' Scientists come to the office, do the research, run the experiments, read technical journals, answer phones, and go to meetings. But they work more than the forty hours a week knowing that they are not paid for extra hours. They come early and leave late. They also take their work home and work over the weekend. What they do at home is related to what they do at work, whereas there is not much link between non-technical workers' work at home and work in the company. In fact, scientists have come to believe that "most good science is done in [their] own time.'' Scientists give all this time because they are interested in the research they are doing. Most non-technical workers, however, work for their hours. If they work extra hours, they are paid overtime; otherwise they do not have an interest similar to scientists in working extra hours.

---

[3]. The American Nurses are the only major professional group who have fought back against proletarianization by the means of unionism (Bellabu & Oribabor 1977). The recent increase in the unionization rates among professionals is almost entirely caused by the rise in government organization (Levitan & Gallo 1989). Furthermore, instead of increased activity and radicalism, alienation and apathy have been the responses to unemployment (Kaufman 1982, Leventman 1981).

One scientist said: ''We are lucky to do what we love to do and get paid for that. It is a great situation.''

Even though scientists' power to decide their research agendas has been severely affected by the restructuring of corporate R&D, the majority of scientists believes that they make choices about what to do and how to do it. ''Management does not come and tell scientists 'do this by such a time'. [Scientists] enjoy a lot of freedom.'' Scientists have more autonomy than non-technical workers because their work is less well defined. In a whole spectrum of working people in an R&D laboratory, scientists have the most autonomy while non-technical workers have the least.

Scientists also believe their ''labor is creative labor.'' For scientists to be successful, they have to come up with good ideas and create something new. Working hard itself is not enough for them, though it leads to new ideas. They have to know how to develop an idea, and how to apply that idea in more than one part of the company. Even if scientists are told to work on certain projects, they have to develop something that was not done before. Non-technical workers, on the other hand, do mostly prescribed jobs. Basically, they are told what to do. They are involved in a routine task, and the more routine the work, the fewer opportunities are available to be creative. The boundaries for scientists are not well established; in fact, they are very wide. ''It is like telling someone to paint a picture. Creativity is very unique to scientists.'' Almost one-third of all scientists regarded their contribution as creative to the company.

The only time scientists considered themselves similar to non-technical workers was when their projects were terminated on non-technical grounds, without their input. Generally, scientists do not succeed in all projects they are involved with. Often, projects get terminated by managers for reasons other than technical failure. When there are persistent disagreements with management over project termination, some scientists start viewing themselves as workers. One such scientist said: ''My feelings have changed. I thought of myself as different from other workers. But, one day the manager came and terminated my project… It seems to me that I am like any other worker from the managerial point of view.'' Most scientists who have had disagreement with the management in the past, however, do not swing to the ''class'' expression. Scientists who came close to regarding themselves as workers during an incident of project termination do not hold on to such an opinion for long. As time passes, they once again viewing themselves as distinct from workers. Scientists recognize the necessity to negotiate with managers around particular issues as they arise.

Interviews with scientists pointed out that their working conditions have been deteriorating with the restructuring of corporate R&D laboratories, but still they are not proletarianized. Does this mean that neo-Marxists are right in regarding scientists as a new class? Scientists overwhelmingly distinguish themselves from workers, as pointed out above. They also differentiate themselves from the managerial class. According to scientists, managers are technical people but they do not share a collegial relationship with the scientists. R&D managers had training and experience in working as scientists before they undertook managerial responsibilities. But scientists believe that the moment scientists become managers they are ''another breed.'' According to scientists, managers tend to lose the perspective of the scientist. Managers formulate and implement a company's policies, and therefore their perspective is different--directed to the goals of the company rather than to scientists.[4]

However, interviews pointed out one major problem in applying the new class theory. Scientists identified various differences and conflicts among themselves, on the one hand, and other professionals such as engineers, technicians, managers, and administrators, on the other hand. Scientists claimed that they and engineers do not constitute a homogeneous category despite the fact that both work in the same lab or on the same project. According to scientists, socialization process differentiates them from other professionals. As scientists go through their education they start thinking according to their disciplines. One scientist explained: ''Since I am a scientist I would not fit with technicians because they are taught differently. Sometimes, technicians have gone through night school to become engineers. But such people have a very difficult transition because they

---

[4]. Dubinskas (1988) found that scientists and managers in genetic engineering firms differ over what goals research should pursue, how the choice should be made, whether direction for research should change, and what projects should be dropped.

have been technicians in their thinking and do not fit the world of an engineer. It is not an economic but a cultural thing which you acquire as you go through the school of science.''

Scientists even acknowledged differences among themselves. They said that scientists with different degrees are given different levels of responsibility. For instance, long term projects tend to go to Ph.D.s, and less significant work goes to M.S. scientists. Accordingly, different scientists show different levels of commitment.

Concluding Remarks

To summarize, scientists overwhelmingly point out that as workers in the companies, they are able to maintain their "career capital.'' Contrary to some Marxists this basic factor is not trivial. The economic foundation of a society is the most important criterion for identifying a class as pointed out by Marxists; a class is characterized by its relation to the means of production. Scientists, like workers, do not control the means of production. However, there is the social and cultural existence of a class along with the economic existence as our interviews with scientists point out. Marxists need to acknowledge the significance of non-economic factors.

Scientists enjoy a considerable degree of freedom within the framework of their company's interests to select their research projects. Scientists, however, do not have unlimited freedom. They have to select their work and decide how to do it within certain limits, which are set by management's funding decisions. Scientists have freedom in their work and enjoy better working conditions vis-a-vis non-technical workers, and this cannot be ignored as in the case of some Marxists, with the notable exception of some like Derber (1982). However, when the generic power of managers is specified, the scientists' freedom does not appear to be important. Scientists are dependent because they have no control over the economy of the industry that employs them, as pointed out by Marxists. In one sense scientists are independent, possessing a distinct measure of freedom on the job that non-technical workers lack. In another sense, scientists are dependent because they have no control over the major decisions of the company. Friedson's

(1986) characterization of scientists as ''workers with special privilege'' is probably the best way of characterizing this complex situation.

Acknowledgement: I thank Karl Francis for useful comments and discussion on an earlier draft of the paper.

Bibliography

Bellaby, Paul, and Patrick Oribabor (1977), "The growth of trade union consciousness among general hospital nurses viewed as a response to proletarianization,'' *Sociological Review*, 25(3), 801-817.

Braverman, Harry. (1974), *Labor and Monopoly Capital*, New York: Monthly Review Press.

Chadwick, Bruce A., Howard M. Bahr, and Stan L. Albrecht (1984), *Social Science Research Methods*, New Jersey: Prentice Hall, Inc.

Derber, Charles (1982), "The proletarianization of the professionals,'' "Managing professionals,'' and "Toward a new theory of professionals as workers,'' in C. Derber, ed., *Professionals as Workers: Mental Labor in Advance Capitalism*, Boston: G.K. Hall, 13-34, 167-190, 193-208.

Dubinskas, Frank A. (1988), "Janus organizations: scientists and managers in genetic engineering firms,'' in F.A. Dubinskas, ed., *Making Time*, Philadelphia: Temple University Press, 170--219.

Barbra, Ehrenreich. and John Ehrenreich (1977a), "The professional-managerial class,'' *Radical America*, 11(2), 7-29.

Barbra, Ehrenreich. and John Ehrenreich (1977b), "The new left: a case study in professional-managerial class radicalism,'' *Radical America*, 11(3), 7-24.

Friedson, Eliot (1986), *Professional Powers: A Study of the Instiutionalization of Formal Knowledge*, Chicago: The University of Chicago Press.

Gorz, Andre (1967), *Strategy for Labor*, Boston: Beacon Press.

Gouldner, Alvin W. (1979), *The future of Intellectuals and the Rise of the New Class*, New York: Seabury Press.

Kaufman, H.G. (1982), *Professionals in Search of Work: Coping with the Stress, Job Loss and Underemployment*, New York: John Wiley & Sons.

Larson, Magali S. (1977), *The rise of Professionalism*, Berkeley: University of California Press.

Leventman, Paula G. (1981), *Professionals out of work*, New York: The Free Press.

Levitan, Sar A. and Frank Gallo (1989), "Collective bargaining and private sector professionals'' *Monthly Labor Review*, 112 (9), 24-33.

Mckinlay, John B. (1982), "Toward the proletarianization of physicians,'' in C. Derber, ed., *Professionals as Workers*, Boston: G.K. Hall, 37-62.

National Science Foundation (1988), *Science and Technology Resources in U.S. Industry*, Washington DC.: U.S. Government Printing Office, NSF88-321.

National Science Foundation (1991), *Science and Engineering Indicators*, Washington D.C.: U.S. Government Printing Office, NSB91-1.

Varma, Roli (1993), *Managing Industrial Science Effectively*, Ph.D. dissertation, Rensselaer Polytechnic Institute, Troy, New York.

Varma, Roli. and Richard Worthington (1993), "Immiseration of Scientists'', presented at the Annual Meeting of 4S (the Society for Social Studies of Science), November 1993, West Lafayette, Indiana.

Appendix:
Methodology

We interviewed scientists of high-technology manufacturing industries because they lead in total R&D expenditures by U.S. companies and employ the largest numbers of R&D scientists (NSF, 1988, p. 43). There are five industries – aircraft and missiles, professional and scientific instruments, electrical equipment, machinery, and chemicals – which are identified as high-technology industries.[5] There are many companies in high-technology industries which have R&D laboratories. We chose two companies in machinery and chemical industries. These two companies have many R&D laboratories, and we chose centralized corporate R&D laboratories. Corporate R&D differs from R&D laboratories associated with business divisions. Corporate R&D aims at performing new product lines and process technology beyond the scope of present businesses. It plays a role when the business divisions are confronted by a problem for which they do not possess the required technical capabilities. R&D laboratories associated with business divisions aim at improving current products or processes. The two corporate R&D laboratories chosen are in many ways typical of other corporate R&D laboratories in terms of size, expenditures, and research activities. They operate independently of any business division and employ over 1,000 scientists and engineers from a broader range of scientific and technical disciplines.

We identified scientists by Ph.D. and M.S. degrees in scientific and engineering disciplines, and employment as research scientists in corporate R&D laboratories. They were selected by a snowball sampling method (Chadwick, Bahr & Albrecht, 1984, p. 66). It began with some *visible* scientists who gave names of other *successful* scientists in their group. The name of the scientist who gave names of others was not used to draw others for interviews. Subjects were selected this way because two companies which were chosen for the research site preferred not to be

---

5. The identification for the high technology industries is based on the concentration of R&D. Two measures of R&D concentration are: (i) total R&D funds as a percentage of net sales; and (ii) the number of R&D scientists per 1,000 employees. These two ratios were 4.7 percent and 43 per 1,000 for all manufacturing industries in 1986 (NSF 1988, p. 40). High technology industries have ratio exceeding both of these averages.

officially involved in the study, but left scientists' participation to their own discretion. At the same time, both companies had a policy of not issuing the names of their employees; consequently, a list of scientists for random sampling was not a possibility.

We interviewed thirty-one scientists from two corporate R&D laboratories. In addition, we selected sixteen scientists who had worked in corporate R&D laboratories and later joined academic institutions. They were considered useful for this study as they were in a position to give outsider perspectives and comments about the reasons behind their moving to academic institutions. Also, they came from different corporate R&D laboratories thus enriched the number of sites. Ex-industrial scientists were selected by scientific and engineering departments in two academic institutions. The department chair identified scientists who had worked in a corporate R&D laboratory. Ex-industrial scientists were then selected on the basis of publications, patents and awards.

The total sample of this study consists of forty-seven scientists. The pretesting of interviews done with six scientists is not included in the total sample. Interviews were conducted from May 1991 to January 1992, and transcribed verbatim by us for data analysis.

Sample Characteristics:

Out of thirty-one industrial scientists interviewed, twenty-seven were male and four were female. Twenty-five male scientists were white and two were of Asian origin. Out of four female scientists, two were white, one was black, and one was Asian. These scientists were employed as researchers. Three scientists held the title of senior scientist, three of group leader, and two of program leader. Most of them had joined industry after finishing their education, and they have stayed in the same company since then. Only two scientists came to industry after teaching in academia for a couple of years, and one had worked in another company for four years. All scientists had been in the present company for a good number of years; two scientists had joined the company in the late-sixties, seventeen in the seventies, and the rest in the early eighties.

Most of the industrial scientists had Ph.D.s; only two had masters' degrees. One M.S. scientist was working towards his Ph.D. after working in the company for eight years. The other M.S. scientist was regarded a successful scientist with over fifty publications and having received the highest technical achievement award given by the company. Scientists' degrees were in a wide range of disciplines such as bacteriology, biology, computer science, electrical engineering, inorganic chemistry, materials science, mathematics, medicinal chemistry, microbiology, organic chemistry, physical chemistry, and physics. These scientists had excellent publication records. Two had published over hundred articles, nine had published over fifty, seven had published over twenty-five, and the rest had published around ten articles. Out of thirty-one scientists, eight scientists had received the highest award given by their companies for sustained technical achievement. Six scientists had received a patent award for the 25th and more patents issued.

Ex-industrial scientists were currently employed in various scientific and engineering disciplines as associate professors and professors in two academic institutions. All sixteen ex-industrial scientists interviewed were male; twelve were white, one was black and three were of Asian origin. They had Ph.D.s in biochemistry, biology, chemistry, computer science, inorganic chemistry, mathematics, metallurgy, organic chemistry, physical chemistry, and physics. They had published well, and many held distinguished awards including a Nobel Prize. Two of the ex-industrial scientists were editors of prominent journals in their field. All had worked in industry for a minimum of five years prior to joining academia. Eight ex-industrial scientists had worked in industry for more than ten years, and two for over twenty years. Some of the ex-industrial scientists had left industry for opportunities to teach and work with students. However, some of them had left industry because there was conflict between their goals and management's. The conflict became apparent in the early-eighties as many corporate R&D laboratories were reorganized.