

ARTICLES

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RESEARCH ENVIRONMENT, MOTIVATION AND PUBLICATION PRODUCTIVITY

1. Introduction

Several studies have shown that the best research environments tend to have the highest publication rates (Pelz and Andrews, 1976; Long and McGinnis, 1981; Fox, 1987). However, this relationship cannot be explained by selective recruitment. Longitudinal studies have controlled for the possibility that the most productive researchers are recruited into the most resourceful settings, and environment was found to have a strong causal effect on productivity (Long, 1978).

Studies of the *work context* describe the impact of autonomy, task organization and distribution of positions and resources on publication productivity. Autonomy refers to the influence that researchers may exert on the definition and shaping of research projects. The question of influence has both external and internal aspects. External autonomy refers primarily to the influence researchers have in relation to financing agencies. According to Knorr-Cetina (1982), such agencies play an important role in decisions concerning scien-

tific work. Thus there is a potential conflict between academic freedom of choice and the influence from financial sources. The internal aspects of autonomy refer to the influence exerted within the organization by its researchers. Studies on internal power indicate that research organizations with high performance tend to have a democratic leadership (Pelz and Andrews, 1976; Blume, 1978). Pelz and Andrews (1976) emphasize the importance of freedom of choice in combination with a moderate amount of work coordination. Autonomy implies not isolation from colleagues, but influence on one's own research goals.

Researchers experience strain in their composite roles as teachers, researchers, administrators or practitioners. Essential issues are thus the way the different tasks are combined, and the time available for research. Results from the Pelz and Andrews study (1976) indicate that the most productive scientists manage to combine research work with other tasks, such as teaching, supervision or administration. However, a critical factor in research organizations is sufficient time for research. In the Pelz and Andrews study (1976), the most productive scientists spent

half or three quarters of their time on research activities; from this the authors conclude that diversity is associated with high productivity. But a general problem in most research organizations is the difficulty of retaining as much as half of the working time for research. A study of Norwegian university scientists (Kyvik, 1983) shows that they spent only 30 % of their time on research. Time available for research would thus seem a crucial factor.

Research tends to be expensive, and access to resources facilitates research. In a study from Norwegian universities, Kyvik (1989) found a weak but significant relationship between financial support and scientific publishing. The same study also indicates that academic rank is related to publication productivity: full professors published more than researchers in other positions. A relationship between rank and scientific publications has also been documented in other studies (Blackburn et al., 1978; Knorr et al., 1979). Promotion to higher positions is of course related to age, but the relationship between rank and productivity holds even when age is controlled for.

The network context provides the basis for communication and contact between researchers, and is important for exchange of ideas, criticism and stimulation. Several studies indicate that face-to-face interaction with colleagues generates research activity (Pelz and Andrews, 1976; Reskin, 1978). Fox (1987) argues that ongoing discussion with colleagues helps activate interest, test ideas and reinforce the work. It has been documented that a high level of social connectedness is linked to research productivity (Biglan, 1973; Finkelstein, 1982). Studies of communication between colleagues have indicated that both the internal and external contexts are important (Thagaard, 1986). However, these two types of networks seem to work in different ways: external networks are particularly important for exchange of information, whereas internal networks provide opportunities for feedback on research ideas and for discussions about projects.

Networks between researchers provide the

context for recognition from fellow researchers. Whitley (1984) argues that having a reputation is especially important for scientists, who -- he claims -- spend much time in convincing others about the significance of their own work. The question remains, however, how important recognition is as a motivational force. There are different points of view on this question. Cole and Cole (1973) emphasize the significance of recognition. They claim that scientists who are rewarded are productive, while those who are not rewarded become less productive. An alternative view -- referred to as the "sacred spark" theory -- claims that scientists continue to be productive even if they are not rewarded (Cole and Cole, 1973). This theory is supported by results from the Pelz and Andrews study (1976) which indicate that a strong inner motivation is associated with high productivity. This inner motivation is described as dedication or a feeling of intense involvement in one's work. Is then the dedication of researchers influenced by qualities of the research environment? The question of possible interaction between dedication and the research environment forms one important focus in the present study.

2. Research design, methods and definition of concepts

The present study concerns the relationship between research environment, dedication towards scientific work and publication productivity. On the basis of previous research, the dimensions in the present study have been defined as follows.

The research environment includes the work context as well as the network context. The *work context* is defined by autonomy, task organization and distribution of resources. "Autonomy" refers to the influence which researchers may exert on the choice and shaping of research projects. "Task organization" has reference to the combination of different tasks and the time available for research. "Distribution of resources" is a question of the possibility to carry out projects

defined as important. These three dimensions influence the possibilities for getting research work published. Publication requires that the research topic is of interest to the scientific community, and that the researchers have sufficient time and resources to produce papers which meet accepted academic standards. Position is a relevant aspect in relation to the research environment. The impact of this dimension will be studied by comparing scientists in different categories of positions.

The *network context* refers both to internal relationships between colleagues (within the organization) and to external (between researchers in different organizational settings). The network context is defined by the frequency of contact and collaboration and by the significance these relationships are considered to have for scientific work. The network context is important for exchange of information as well as reactions to one's own projects. Communication with colleagues may activate research interests, thus facilitating publication productivity.

Motivation or dedication is defined according to the priority that scientific work has for the researchers. For the highly dedicated, research work is of main interest. Low dedication is here defined by a preference for tasks other than research work (such as teaching or administration).

The *sample design* represents variations in the research environments. Half of the scientists in the sample are from university departments and the other half from institutions of applied research. Both male and female scientists were interviewed. The most characteristic variation between university departments and institutions of applied research concerns autonomy in relation to the choice of research projects. Norwegian universities are publicly supported, and university scientists have, in principle, a high degree of autonomy concerning the selection of research problems. Applied institutions are mostly financed by specific project work, whether publicly or privately funded. In contrast to the universities, research at applied institutions must take place within the scientists' own fields. Thus, in principle, university scientists

have greater autonomy than their colleagues in applied institutions, both concerning the choice of research problems and the extent of projects. In the presentation of data, possible differences in autonomy between university departments and institutions of applied research will be discussed.

Within each institution, the sample was stratified by type of position. The sample represents full professors and associate professors. Research assistants and persons below the age of 35 were not included in the sample, because the study focuses on researchers with a relatively long experience of research work. The sample reflects the skewed distribution of research positions in Norway, with relatively few full professorships and more positions as associate professor. The ratio between full professors (and the equivalent researcher I in applied institutions) and associate professors (and the equivalent researcher II) in the sample is 2:3. Research careers in Norway are characterized by relatively few chances of vertical mobility. Until recently, full professorships could be obtained only when one of these positions happened to fall vacant. In recent years, however, it has become possible to become a full professor also via promotion, and this has increased the opportunities for vertical mobility to some extent. The rate of horizontal mobility is also relatively low, especially at the universities. Salaries are uniform at all universities, and there are only small differences in prestige between various institutions. These structural aspects give few incentives for moving from one university to another.

Several studies have indicated that research environments operate differently for men and for women (Luukkonen-Gronow, 1987; Fox, 1988). Thus, it was considered important that both men's and women's experiences should be included in the study, and fields with a relatively high proportion of women were chosen. The selection of fields had to meet two criteria: 1) they had to represent research both in universities and in institutions of applied research, and 2) the proportion of women should be relatively high. The combination of these two criteria gave

the following selection of fields: Chemistry, Biology and Psychology. The sample consists of 20 scientists from each field, 10 of these from university departments, and 10 from institutions of applied research. The total sample thus includes 60 scientists.

The data for this study are represented by interviews and publication lists for each person interviewed. The interview situation was open and unstructured. The interviews took place at the office of the subject and lasted from 1 to 1 1/2 hours. The topics covered were primarily associated with the work situation. Relevant dimensions were the financing of research, the structure of leadership, the organization of work, networks within and between research organizations and the distribution of rewards. All interviews were recorded and transcribed onto computer disks. Quotes from the interviews will be used to illustrate important points.

The publication data provide the average rate of each scientist's publications, as well as variations during his/her career. These data were calculated as the average number of articles per year, with an edited volume considered the equivalent of 2 articles. Research reports and books were considered the equivalent of 3 or 4 articles, depending on the size, and textbooks were considered the equivalent of 3 articles. On the basis of the yearly publication rates, graphs representing the publication history of each scientist were made, a way of displaying career profiles previously used by Cole and Zuckerman (1987).

The present study combines qualitative and quantitative data. Interviews form the primary source of data, and the qualitative approach is emphasized in the design of the study. The main purpose underlying the analysis of interview data has been to study research environments from the scientists' point of view and to develop concepts relevant for understanding the scientists' relationship to their environments. Since the data are not based on a probability sample, the distribution of scientists in different environments is not important. Differences in the quality of environments are the focus of inquiry. The interview

data are combined with quantitative data on publication productivity.

3. Variations in research environments.

How do research environments vary between university departments and institutions of applied research? The main difference between these institutions is that researchers at universities have greater autonomy in the definition of research problems. However, structural conditions such as time for research and financial conditions are in general better at applied institutions. On the whole then, there are no substantial differences in the overall quality of research environments between university departments on the one hand, and institutions of applied research on the other. This result is reflected in the publication data, which indicate a negligible difference in publication between university departments and institutions of applied research. Thus, type of research institution is not an important dimension in the study of relationships between research environments and publication productivity.

Several studies indicate that the publication rate varies between disciplines (Cole, 1979; Andersen, 1987; Kyvik, 1989) and between research groups (Knorr et al., 1979; Luukkonen, 1990). These variations do not, however, show a consistent pattern. A study from the USA indicates a higher publication rate for chemists than for psychologists (Cole, 1979). Data from Norway, however, show a lower publication rate for chemists compared to biologists and psychologists (Kyvik, 1989). In the present study, the difference in publication rates between chemistry, biology and psychology was found to be negligible. Thus, scientific discipline is not an important dimension in the study of relationships between research environments and rates of publications. The variations in quality of research environments presented in this paper accord with differences in the structural conditions of research groups documented in other studies (Knorr et al., 1979; Luukkonen, 1990).

According to the descriptions provided by

the respondents, 24 are associated with good environments, 22 with medium environments and 14 with non-facilitating environments. What do these differences imply? How do these categories of environments differ more specifically? Differences in research environments will be discussed according to the dimensions described as important: autonomy, organization of tasks, distribution of resources and networks between scientists. Primarily, good and non-facilitating research environments will be compared. Medium environments are classified in-between.

Autonomy is a question of influence from scientists in relation to impact from other groups, especially financial agencies. Influence will always have to be divided because the choice and shaping of research projects depends on financial support and available equipment as well as research interests. There are, however, great differences in the amount of influence exercised by scientists. A good environment is characterized by much influence from its researchers. This can be illustrated by the following statement: "I have always had a lot of influence on my research. The choice of research problems is based on my interests". Non-facilitating research environments are characterized by low autonomy, which implies that research projects are defined primarily by institutional leaders or financial agencies. This can be illustrated by the following statement: "The choice of research projects in my research group is based primarily on financial possibilities. Our own research interests play a secondary role".

Organization of tasks defines the amount and combination of different duties. Considerable strain is involved in composite roles, and the crucial question is the time available for research. Scientific work is time-consuming -- one can never have enough time. But there are great differences in the amount of working time for research, and especially in the possibilities for concentrated time. Scientists in good research environments have between 1/3 and 1/2 of their working time for research, and they are able to concentrate more on research work in periods when the research is particularly demanding. One of

the scientists associated with a good research environment describes his work situation like this: "No matter how many engagements I have, I keep two days a week for research work. And I have certain periods each year when I can concentrate completely on my projects". In non-facilitating research environments, other tasks are too demanding. The time available for research is hardly sufficient to keep projects going.

Most research, especially in the natural sciences, is resource-demanding. And with *resources*, there is a similar tendency as with time: one can never have enough. One main difference is between those who have sufficient resources to engage in projects on the research front, and those who have to keep their research on a less resource-demanding level. Scientists in good environments have sufficient resources to engage in projects of competitive quality. This can be illustrated as follows: "Our group has first-class equipment, which makes us able to compete internationally". In non-facilitating environments, lack of resources is considered a problem in relation to the quality of research. The following statements illustrate this: "We do not have enough resources to work on the research front. In order to compete internationally, we need more personnel and more resources". "We do not have enough resources for the type of projects I am working on. I use large-scale equipment and need technical assistance, but this is impossible to finance".

Participation in networks includes contact with scientists in one's own institution as well as with colleagues elsewhere. There are variations both in the amount and quality of contact with colleagues, and to what extent the contacts are primarily in one's own organization or with other scientists in other institutions. The data indicate that lack of communication about research in one's own organization can to some extent be compensated by external contacts. Thus, it is not important to make a distinction between internal and external networks. The focus is on the frequency of contacts and the significance these have for scientists. Scientists in good environments have many contacts, and they derive consid-

erable feedback and inspiration from these. The significance of research contacts can be illustrated as follows: "My scientific contacts are very important for my work. Questions about my research and references to my papers are stimulating and challenging". One scientist with many international contacts describes the importance these have for him: "My international contacts are absolutely necessary for my research. To participate internationally is the most rewarding aspect of my work". In non-facilitating environments, lack of communication about research is considered a problem. One scientist says: "I have few research contacts and consequently, I miss communication with colleagues. I think I would have been more productive if I could have discussed my research more with colleagues".

Altogether, a good environment is characterized by high autonomy and sufficient time and resources for high-quality research. Scientists have many contacts and these are considered important for their research. The definition of a good environment need not include all of these criteria, but it should embrace most of them. Non-facilitating environments have opposite values on all or most of these dimensions. Medium environments are characterized by high values on some dimensions and low on others, or medium values on all dimensions. During the analysis of data, the influence from individual scientists on organizing research proved to be an important factor. To what extent do members of research organizations contribute to developing their own environment? This question will be discussed more closely below.

4. Research environments and attitudes towards work: towards a typology of scientists

In describing the research situation, *dedication* to scientific work was an important dimension. The analysis of data focused on the relationship between dedication to scientific work and the research environment. High dedication implies that scientific work is preferred

to other tasks: "My abilities and interests go primarily in the direction of research. If possible, I would prefer to spend all my time on research". The results indicate a mutual relationship between dedication and the research environment. A good environment increases dedication to scientific work, and highly dedicated scientists create a stimulating environment.

The impression of influence from individual scientists was strongly emphasized by another motivational dimension which proved to be important during the analysis of data. This dimension is referred to as *motivation for organizing research*. The data indicate that about half of the scientists in good environments were highly motivated to organize research and had been active in organizing their research environment. This dimension implies activity in establishing contacts and in the development of research groups. The following description illustrates this: "The first thing I did when I started this job was to recruit co-workers. We have had this large project going for several years and it has initiated many publications".

Scientists active in organizing research describe a busy work life with extensive engagements and long working hours. One of the persons interviewed in this category describes his work schedule like this: "My days are so busy, I have to use evenings, weekends and holidays for my research. I have not had a real holiday for years". The working pattern described by these scientists implies not only a heavy work load but also a life style where work has a particularly high priority. The values involved can be illustrated as follows: "You sacrifice financial gain, private life, -- and most other things. You may ask yourself if it is worthwhile, but at least for me it is". The value aspect of this work style implies that an element of personal choice is involved. Extensive work engagements seem to be a preference for many of these scientists. This category is referred to as research organizers. In contrast to this group, there are other scientists who emphasize lower career ambitions, as can be seen from the following statement: "I am satisfied with one or two publica-

tions a year. There is no time for more in addition to teaching and advising students". And they express a preference for a less extensive work pattern: "I do not want to get involved in too many activities. I prefer to concentrate on my projects". Another says: "I do not want to work during evenings and weekends. I want time for other things".

The combination of the quality of the research environment, motivation for organizing research and dedication to science represents a basis for a typology of scientists. Another relevant dimension in this context is position held. Full professors and researcher I are classified as higher positions in Table 1, which describes the typology and its basic dimensions.

The scientists classified as *entrepreneurs* and *network builders* represent the research organizers. They are associated with good research environments and are usually characterized by high dedication to scientific work. The data indicate an especially high proportion of scientists who are full professors or researcher I for these two categories, and one may assume that there is a relationship between higher positions and activity in organizing research. Achieving higher positions may be based on high activity, but the relationship might as well be the opposite: higher positions may provide better opportunities for organizing research. The difference between these two categories concerns the direction of their organizational activity. *The entrepreneur* is active in organizing research teams, in obtaining resources and assistants, and in establishing contacts. *The network builder* directs his or her organizational activity mainly towards other institutions or other countries.

Research performers are characterized by

high dedication to science, and they are associated with good research environments. The proportion of scientists who are full professors or researcher I is lower for this category compared to the research organizers, which may be associated with the work pattern. The research performers explicitly emphasize that they prefer to perform all aspects of the research themselves, as can be illustrated by the following statement: "I prefer to do all research work myself. The lab work, the planning and writing of publications. I would not consider myself a real scientist if I did not do the lab work myself". Many in this category emphasize a preference for a less extensive work schedule in order to have more time for family life and personal interests.

Scientists associated with a medium research environment are characterized as *opportunity-limited*. The research environment is not particularly facilitating; there are relatively few higher positions and the scientists are often characterized by a medium dedication to science. There is obviously an interrelationship between a less encouraging environment and lack of primary involvement in research work. It may be difficult to tell whether the environment or dedication is the crucial factor. Importantly, there is a particularly high number of scientists in this category.

There is to some extent an interrelationship between a non-facilitating research environment and low dedication to science. A non-facilitating research environment does not inspire research work, and low dedication to science does not enrich the environment. However, a main distinction between scientists associated with a non-facilitating research environment goes between those who explic-

Table 1: A typology of scientists.

| environ- ment | dedita- cation | research organizing | categories | (N) | higher positions |
|------------------|-------------------|------------------------|---------------------|------|---------------------|
| good | high | high | entrepreneurs | (6) | (5) |
| good | high | high | network builders | (6) | (3) |
| good | high | low | research performers | (11) | (4) |
| medium | medium | low | opportunity-limited | (23) | (3) |
| non-fac. | low | low | administrators | (8) | (1) |
| non-fac. | medium | low | isolated | (6) | (0) |

itly favour other tasks and those who do not. Scientists who give priority to administrative tasks are classified as *administrators*. Administration in this context refers not to organizing research projects, but to duties related to the running of departments, institutes or other types of organizational set-ups. One of the respondents in this category characterizes her work like this: "I like administration. I like to organize and get things going. I am not the type who is really dedicated to scientific work".

Scientists associated with non-facilitating environments and not dedicated to specific non-research tasks are classified as *isolated scientists*. They have little support from their colleagues and the work conditions do not facilitate research. In the description of their situation, these scientists emphasize the lack of opportunities in the research environment. There are no higher positions in this group, which may be associated both with characteristics of the environment and dedication to research.

5. Categories of scientists and variations in publication productivity

The results confirm tendencies from other studies which indicate that publication productivity varies with qualities of the environment. However, when studying the categories in the typology, the variations in publication productivity become more specified. Two types of publication data will be presented: average rates for each category of scientists, and profiles for typical careers in these categories. Since the rate of horizontal mobility is relatively low, most scientists have the same research conditions throughout their tenure years. The network context may change during the scientist's career but the number of contacts tend to be relatively stable throughout the career as a senior scientist. This simplifies the relationship between research environment and publication productivity. Table 2 shows the relationship between categories of scientists and publication productivity.

Table 2 indicates great variations in publication productivity between the different cate-

Table 2: Research environment, categories of scientists and publication productivity. (The publication rate describes the average number of publications pr. year. The publication period includes the time from university graduation until the year of interviewing). The number of scientists is lower here than in table 1, because 6 of the scientists did not present their publication list.)

| environment | categories | average rate of publications: | (N) |
|-------------|---------------------|-------------------------------|------|
| good | entrepreneur | 5.1 | (6) |
| good | network builders | 3.7 | (6) |
| good | research performers | 2.2 | (10) |
| medium | opportunity-limited | 1.8 | (20) |
| non-fac. | administrators | 1.1 | (7) |
| non-fac. | isolated | 1.2 | (5) |

gories. Entrepreneurs and network builders exhibit the highest rate of publications, while administrators and isolated scientists have the lowest publication rate. These results can to a small extent be influenced by an unequal distribution of men and women among the categories of scientists. There are only 4 women among the research organizers, and these women have a lower publication rate than their male counterparts. Thus the particularly high rate of publications among the entrepreneurs and network builders may be explained by the high proportion of men in these categories. In the other categories of scientists, the differences in publication rates between men and women are negligible and do not influence the results in Table 2. The data show a considerable difference in the overall publication rates for men (2.7) and women (1.9) but this difference can be explained by the fact that male research organizers publish more than their female counterparts.

How can the differences in publication rates between the categories of scientists be explained? The rate is especially high for *entrepreneurs*, with an average rate of 5.1 publications pr. year. Also the *network builders* rank high, with an average of 3.7 pr. year. These high publication rates can be associated both with stimulating environmental conditions and with high dedication to scientific work. In addition, the high activity in organizing research which characterizes scientists in these categories implies that publication is largely a

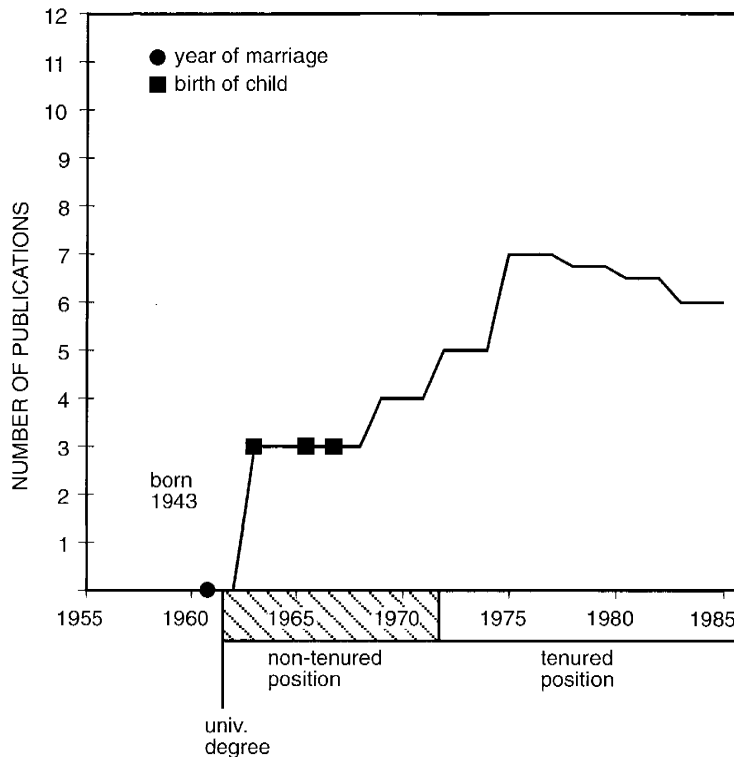


Figure 1. The publication profile of a married, male scientist with three children. His publication pattern has increased towards a high level, and he has continued to publish at a high rate.

result of contributions from others, such as assistants, temporary visitors in the research group or colleagues. The extensive networks of these scientists mean that they are often invited to give lectures and present papers, which are later published. Thus the high publication rate for research organizers is associated both with their communication channels and with their work pattern as such.

What characterizes the publication profiles for the entrepreneurs and network builders? An illustration of a characteristic career profile for these categories is presented in Figure 1.

Characteristic of this profile is a strong upward trend during the early part of the career. This upward trend can be associated with good scientific training during the early years of the academic career. All the scientists in these categories stated they were satisfied

with the training they got during the years before they achieved tenure. Characteristic aspects of good training are qualified supervision, early establishment of scientific contacts and practice in writing papers. The typical publication profile shows a publication peak after 10 to 12 years of career, after which approximately the same level of publications is maintained throughout the career. This pattern is shown in Figure 1. We associate the high steady level of publications with a good working environment.

Research performers have a lower publication rate, averaging 2.2 papers pr. year. These scientists have the advantage of being associated with a good environment. But compared to the research organizers, they are less active in organizing research, which implies that their publications are to a less extent based on contributions from others. Their

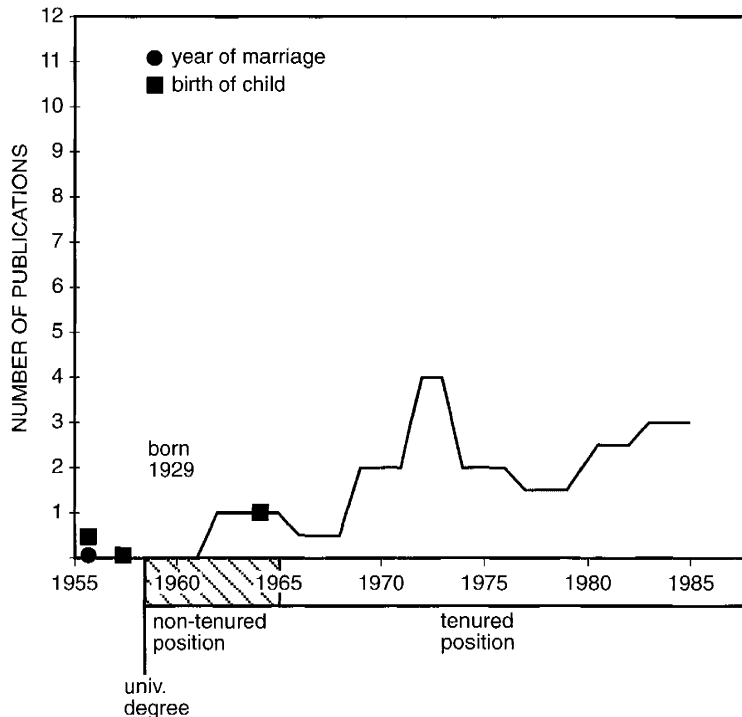


Figure 2. The publication profile of a married, male scientist with three children. His publication rate has increased towards a medium level, and after a short period characterized by a higher rate of publications, he has continued to publish at a medium rate.

networks are less extensive, so they have fewer invitations to give lectures and present papers. The lower publication productivity of this category can thus be associated with less input from others and a preference for less extensive work engagements.

Compared to that of research organizers, the publication profile of research performers is characterized by a limited upward trend during the early part of the career. The curve then levels out, and the scientists maintain approximately the same level of publications throughout their career. Some show relatively great periodic fluctuations, but on the average, the level remains approximately the same. Figure 2 illustrates the publication profile for one of the research performers.

Most of the scientists in this category have had a good start concerning supervision and research training. Thus the early career is similar to that of the research organizers. But

the career profile does not show the strong upward trend that we found for the research organizers.

Opportunity-limited scientists have a somewhat lower publication rate compared to research performers: 1.8 publications pr. year. According to the scientists' descriptions, this publication rate can be associated with limitations in the environment. However, we do not know whether the crucial factor is lack of opportunities in the environment, or reduced motivation for scientific work. The two dimensions are probably interrelated. The publication profile for these scientists shows a similar pattern to that of research performers: a slow upward trend in the beginning of the career, then the publication curve levels out. The training years for this category are described as less satisfactory than the pattern we found for the research performers.

Both *administrators and isolated scientists*

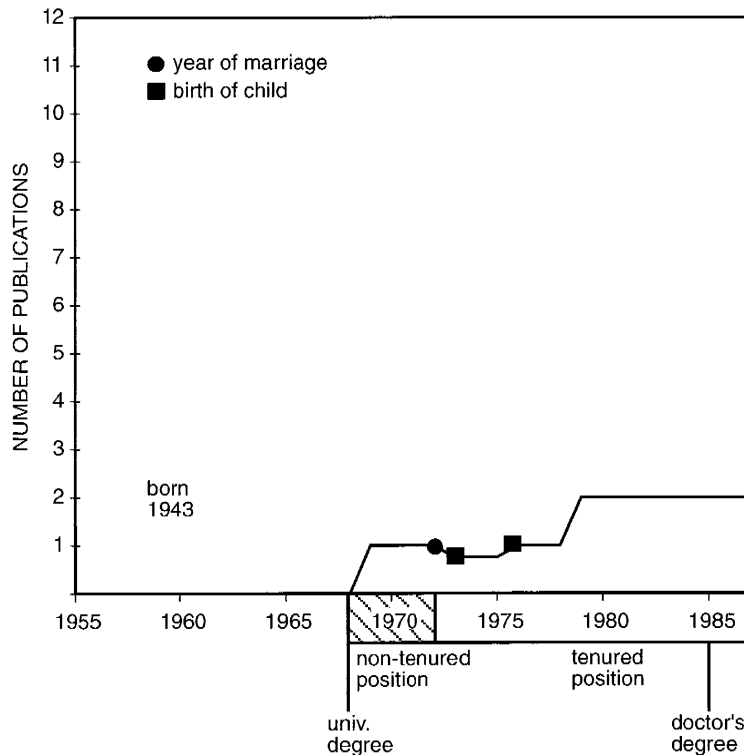


Figure 3. The publication profile of a married, female scientist with two children. She has published at a rather constant low rate throughout her career.

have a low average publication rate: 1.1 and 1.2 respectively. A non-facilitating research environment may be an important explanatory factor for both these categories. For the administrators, a preference for activities other than research is probably also associated with the low rate of publications. However, it is also a question whether little success in science and perhaps also a non-facilitating environment are the basis for preferring other tasks, or whether a low dedication to science was crucial in the first place. Isolated scientists emphasize very explicitly that they suffer from lack of opportunities in their environment. There may be a vicious circle here, because a low publication rate may reduce one's chances to improve environmental conditions, just as a high publication rate may increase the chances of obtaining resources.

The publication rates for both these categories of scientists show a steady flow of a

small number of publications each year. There are yearly and periodic fluctuations, but these are rather small. The main pattern is one or two publications each year. A characteristic publication profile for these categories is presented in Figure 3.

The data indicate that there is no upward trend in the beginning of the career in the publication profile presented in Figure 3, -- a typical pattern among administrators and isolated scientists. It is interesting to note that most of these scientists have either received no research training or have had little benefit from a few years of research training.

Altogether, then, the data presented above lead to the conclusion that the categories of scientists in the typology are associated with great variations in publication productivity. Scientists in good environments who are active in organizing research (entrepreneurs and network builders) have the highest publica-

tion rate. Scientists in good environments who are less active in organizing research (research performers) and those in medium research environments (opportunity-limited) have a medium publication rate. Scientists in non-facilitating research environments (administrators and isolated scientists) have the lowest publication rate of all.

6. Conclusion and comments

One conclusion to be drawn from this study is that both quality of the research environment and dedication to scientific work are associated with publication productivity. The implication is that autonomy, organization of time and resources, and collegial contact all influence the rate of publication. Since the sample in this study is relatively small and of a non-probability type, it is especially important to note that these findings support results from other studies. Pelz and Andrews (1976) stress the combination of autonomy and contact with others: "maximum performance occurs when the scientist has both high influence and the involvement of several others" (p.19). Both the Pelz and Andrews' study and data on Norwegian university scientists (Kyvik, 1989) indicate that financial support and concentrated time for research serve to facilitate publication productivity. The significance of communication with colleagues for activating interests, testing ideas and reinforcing work is documented in many studies (Pelz and Andrews, 1976; Reskin, 1978; Fox, 1987; Kyvik, 1989).

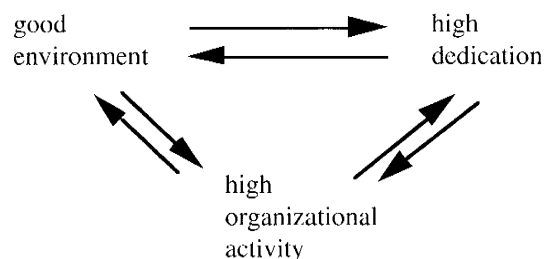
The impact of scientists' dedication to work is especially emphasized in Pelz and Andrews' study (1976). They write: "the feeling of intense involvement in one's work -- called dedication or commitment, -- was consistently found among high performers in numerous settings" (p.88). In the present study, dedication to science is an important dimension, especially in relation to the research environment.

A second conclusion from this study is that the interrelationship between qualities of the research environment, dedication to science

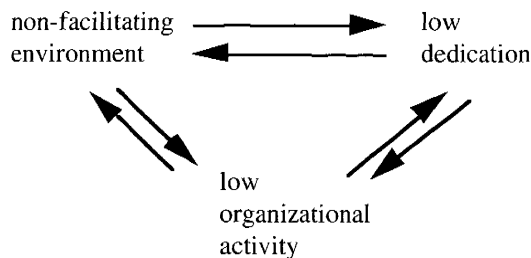
and motivation for organizing research can explain variations in publication productivity better than environment alone. The relationship between these dimensions can to a great extent be explained by the theory of cumulative advantage (Merton, 1973). This theory emphasizes a mutual interaction between the work situation, the network context and dedication to scientific work. A good work situation may lead to increased research effort, which again may activate recognition from fellow scientists and thus contribute to increased contacts with colleagues. Recognition from fellow scientists may also improve one's academic position and increase dedication to scientific work. On the other hand, reduced research effort may be explained by cumulative disadvantage.

Findings from the present study confirm this theory, but the data also imply that the theoretical perspective can be extended. The high organizational activity characteristic of many of the scientists in good research environments emphasizes the role of individual scientists in shaping their work context. The initiative and effort of individual scientists are important to the development of a good research environment. To a great extent, scientists active in organizing research create their own research environment. Since the combination of organizing and performing research is time-consuming, the implication of this work pattern is that such scientists give priority to extensive work engagements and a long working week.

The relationship between a good research environment, high dedication and high organizational activity can be illustrated by the processes which characterize scientists with a high publication rate:



The initiative and effort associated with high organizational research activity may contribute to the development of a good research environment. And a good environment may provide many opportunities, which, in turn increases organizational activity. Another implication is that highly dedicated scientists may create a stimulating environment and that good environments may increase dedication to scientific work. High dedication may also lead to high organizational activity, and vice versa. Altogether, the results lead to the conclusion that the interrelationship between high organizational activity, high dedication and a good research environment accounts for high publication productivity.



By contrast, the scientists with a low publication rate are characterized by almost opposite processes. They show low research activity, both concerning performing and organizing research. These aspects are reinforced by a non-facilitating research environment and low dedication to scientific work. Low dedication may imply low organizational activity, and vice versa. The question of individual choice is less relevant in this context. A non-facilitating research environment provides few opportunities for developing good research conditions. The possibilities for choice are greater for scientists associated with good research environments.

Thus, the perspective developed in this paper emphasizes the relationship between research environments on the one hand, and motivation and effort of individual scientists on the other. This perspective stresses the importance of focusing on the role of individual scientists in the study of research environments. However, the interrelationship between

research environments and organizational activity has reference not only to the current work situation, but also to the organizational and network contexts in the early years of a scientist's career. Thus yet another implication of this paper is to emphasize the importance of studying socialization to scientific work.

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