

**Careers in R&D: Methodological considerations
on a process**

S. van Diepen

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S. van Diepen
University of Limburg/MERIT

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Abstract.

This paper deals with some methodological issues connected to organization research, in specific connected to research on innovative behaviour in organizations. First our object of research will be described (section 2). After that, methodological considerations follow with regard to a process theory, which is regarded as indispensable for our research purposes (3). Thirdly, some guidelines are illuminated for this specific application of process theory. In that section we deal with events, and sequences of events, as elements of process theory (4.1). As indicator for the measurement of events, relevant career periods will be used, as indicated by the research subjects themselves (4.2). Several problems are associated with this indicator, which will be dealt with explicitly. Then, the method for analyzing events and sequences, as used in this project, will be explained. Some results will then be presented, based on sequences of experience (5). After that, implications for innovation and personnel policy are being focused on (6).

1. Introduction

This research project concerns a contribution to the development of knowledge with respect to innovation and the specific organizational context of innovation. The innovation process is complex and various process phases interrelate but differ in their determinants for success. Before we can determine whether and what controls are feasible within R&D, we have to consider the origin and reason of the occurrence of innovative activities. Only if we can explain the nature of this process, do we have a fundament for policies for the management of the innovation process. The process we focus our attention to, is the development of individuals' abilities by engaging in innovative action, and the means by which organizations stimulate or impede this development.

2. Innovative behaviour in organizations

Organization studies should be concerned with outcomes rather than independents (Mohr, 1982). Where a greater percentage of work becomes highly skilled and professionalised, and markets are rapidly changing or competition is fierce, innovation is the single most important outcome variable of organizations (Staw, 1984). In studying innovative behaviour, a pure structuralist's approach of artificially isolating innovative actions in time is unproductive. We cannot explain their occurrence as a result of organizational structural, environmental, and individual characteristics all taken at one point in time. As such, innovation is a process of organizational change. Dosi (1988) describes innovation as the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups. By using this definition as a starting point;

1. the dependent variable is durable, since it has constant meaning and it is a potential behaviour in all times;
2. the focus is on a process rather than a conduit and;
3. processes prior to commercialization of new products and processes -such as invention- are explicitly dealt with.

The renewal process of innovation requires changes in the organizational routines, which include the forms, rules, procedures, conventions, strategies, and technologies around which organizations are constructed and through which they operate.

Although innovations replace existing organizational routines, innovations relate, are constrained by, and even build upon these prior routines. Hence organizations follow trajectories of technologies (Nelson et al., 1982). The effective use of one routine, depends on the extent to which previous inferior routines have been efficiently used by the organization, without falling into the competency trap of accumulating experience with the inferior routine because of its favourable performance. This gives rise to the conclusion that research on innovation needs a perspective in which innovation is viewed as a historical cumulative development in which new ideas unfold and become commercially exploited. Understanding the genesis of innovations

requires an understanding of the role that learning processes have in the context of innovation.

Among critical components of the institutional capacity to innovate, are the abilities to make use of prior external and internal knowledge, either by individuals, groups, organizations or even nations. Empirical research has indicated that failures on one or more earlier attempts, often precede success in the innovation process (Maidique et al., 1985). What is needed, is the empirical study which bridges the gap between research on individual and group innovative actions and organizational innovation. In specific, the significant and difficult work that needs to be undertaken is the examination of how individual, group, and organizational factors interact to make an organization innovative (Staw, 1984). It is the person that brings specific intangibles with him, such as knowledge, skills and motivation, but organizational characteristics limit or facilitate what will be attempted, what will be noticed, and what will be possible (Angle, 1989). There is a need for a body of knowledge how this creative process works, how it actually is controlled, and how it relates to previous individual and organizational experience, through organizational learning.

The problem is that this can hardly be done in a single research project. Here we will concern ourselves with the individual level of action for theoretical and practical purposes. If we wish to understand the innovation process and the ways in which the idea generating and subsequent phases of the innovation process can be managed, we need to devote attention to the ways that participation in this process changes people over time, thereby determining the future innovative capacity of these same individuals (or aggregates of individuals). It would be interesting if the earlier mentioned path dependency of innovative behaviour could be assessed. Although this may probably differ from other levels of analysis. A practical problem for organizations rests with the durability of challenging tasks and effective performance of the workforce. Assessment of paths with different career effects could have important implications for this career management.

3. Process theoretical approach

Organizational behaviour is an interdisciplinary field that examines the behaviour of individuals within organizational settings as well as the structure and behaviour of organizations themselves. As such the field has made only little progress in terms of cumulativeness, with a lack of reasonable and warranted stability in results, as a major obstacle (Mohr, 1982). A change in research tactics is necessary, where emphasis goes from searching for efficient causes (push-type causality) to searching for final causes, from precursors as necessary and sufficient conditions to precursors as necessary conditions only. These serious improvements can be made when research moves to a focus on the development of process theory rather than variance theory.

Studies of organizational change tend to focus either on the antecedents and consequences of changes, or on the way the change emerges, develops, grows or terminates over time (Van de Ven et al., 1990). In terms of an input-process-output model of change, the first variant focuses on inputs and outcomes of change, entailing variance theoretical explanations. Criteria for outcomes (dependent variables) explaining inputs (independent) are covariance, absence of spurious associations, and temporal precedence of the variables. The second variant uses process theories which focus on sequences of events or stages in the process part of the model of change. Here change is explained in terms of underlying generative mechanisms and the particular circumstances when these mechanisms work. By first finding a sequence of events to exist, questions which rise about antecedents and consequences of these sequences in the change model, can be turned to. The next section deals with these sequences.

The second reason for concentrating on the process of innovative behaviour rests with the possibility of addressing paradoxical issues that characterizes the innovative behaviour of individuals in organizations (Quinn et al., 1988). One of these paradoxes exists with regard to control by means of formal policies and procedures.

They are required in organizations to ensure the proper behaviours of people in organizations, by means of coordinating, thereby increasing efficiency and improving competitiveness. In contrast, innovation and creativity, by definition imply the violation of practices and procedures, and are inhibited by adherence to formal organizational policies. Reliance on other (informal) control mechanisms such as clan control or personnel control seems more productive in creative settings (e.g. R&D). However social controls also tend to reduce an organizations ability to adapt to a changing environment by means of induced conformity. This, in return, may stifle creative approaches to organizational problems (Merchant, 1985). A process approach to studying innovative behaviour may contribute to the questions when different control instruments are productive in the innovation cycle, and how these relate to employee experience.

4. Guidelines for process analysis: Analyzing sequences of events.

As mentioned previously, our level of action in research on the process of innovative behaviour, is the participation and change of individual research and development employees in innovative activities. The latter are the central subjects of this research. The sequences of social events thereby contains of the career tracks of these individuals. As in standard research methods, extensive care must be taken with conceptualization and measurement. This involves on the one hand colligation - making up a basic story of conceptual events and linking them together- and on the other, distinguishing indicators (occurrences) from the concepts (events) (Abbott, 1990).

4.1. Conceptualizing on R&D career tracks.

The task of conceptualizing boils down to the assembly of a story that can legitimately be assessed in a set of data. Analogous to establishing the variables model in standard techniques, a decision has to be made about the essential events and about the essential mechanisms believed to propel the story from one to the next

(Abbott, 1990). As mentioned in the previous paragraph, the research level of action is the career. A career can be defined as "a sequence of roles or positions, usually related in work content, through which employees move pulled by opportunities in the organization ..." (Milkovich et al.1982, p.365). Thus, critical in careers are the subsequent assignments individuals receive. These are not treated as the surface level result of a stochastic choice process (the opportunities) with parameters and constraints. Rather, careers are taken as wholes. Their history is thereby not the reflection of the real regularities in the mechanism. The careers are the regularities themselves. This enables us to study careers as they occur to us, instead of having to investigate population mechanisms.

Careers can be considered as discrete ordered samples of recurrent events in a temporal development. An event is considered to consist of a merger of a person P with experience E with job J , the latter being a combination of activities A with technology T . Accordingly at t_1 the event $P_1E_1J_1$ takes place, which can also be written as $P_1E_1A_1T_1$. This type of event is recurrent, because the assignment is repeated, although the combinations may be different each time and the duration of the combinations may differ. If the event finally is the persons' last assignment, this results in his final experience with final performance. Hence, the career of individual P_1 can be viewed as a sequence

$$P_1E_1A_1T_1 - P_1E_2A_2T_2 - \dots - P_1E_tA_tT_t$$

In Appendix A the issue of measurement of PEJ-combinations is further explained.

Questions that arise, when data can be represented as sequences of events are, whether typical sequences exist, or whether sequences can be classified in families of sequences (1), what causes the patterns to be the way they are (2), and what the consequences are of given sequence patterns on other variables (3) (Abbott, 1990). The third question will be of interest later. For instance, the path which each individual goes, is assumed to influence his final expertise. In terms of experience paths, patterns of growth will differ from patterns of decline. These relate to the knowledge accumulation process which typically is inhibited by lock-in, or lock-out

experiences. But they will lead to a different final assignment as well. Assuming that the employer uses signals from employee's past (e.g. his experience), R&D employees can be more or less better off in the tasks they are assigned to, with respect to autonomy and control. In Rosenbaum's (1989) tournament model, which is typical for organization selection models, careers are conceptualized as a sequence of competitions, each of which has implications for an individual's mobility chances in subsequent selections. Employees in high status or demanding jobs are viewed as winners of past competitions, and consequently as more able. Winners may compete for higher levels, however without the assurance of obtaining those jobs, and losers are relegated to minor tournaments for lesser positions. Thus, the career tournament retains losers but lowers and narrows their options. This way, the tournament model defines constraints on the career options of individuals at each stage of selections. Rosenbaum (1989) states that when abilities are hard to measure, firms use past education and job attainments and career velocity as surrogates in this selection process. This way, careers may determine the future assignments. However, a further elaboration on this subject is beyond the scope of this paper.

4.2. Measurement of events; from concept to indicator

The concept of PEJ-combinations (events) is measured temporally, by assessing changes in PEJ-combinations which R&D employees encounter during their career (occurrences). In standard methods, exploring the causality of a particular development for the variance in output variables, calls for a (quasi-)experimental design, with pre- and postdevelopment measurement (direct observation). Ideally, such assessment should be done in a longitudinal field research design, or panel design, enabling the researcher to make a valid estimate of the effects of various developments. However, given the nonexistence of such data, the time restrictions to measurement of career changes, and the general scarcity of organizations which expose themselves to extensive empirical research, an alternative design was selected. Analogous to previous investigations (e.g. Gerpott, 1988, Glick et al., 1990) a retrospective research design was chosen, asking respondents to

retrospectively report their past career, thereby discerning a finite number of relevant and dissimilar periods. By using this method, different career periods could be discerned per respondent. To avoid inconsistency across respondents in narrating the events, and in order to limit the use of respondents' time, a computerized interactive structured survey instrument was used. Respondents reported on their career in at maximum 5 steps, each one consisting of approximately 80 items. Because the hypothetical distribution of the events over all subjects is a infinite continuous time interval, this retrospective method avoids the problem (e.g. of panel research design) of different periodicity of measurement and changes in PEJ-combinations. Appendix B entails the instructions respondents received to describe their careers.

A disadvantage of the method using subjects as observers and interpreters of their own history, is that the reports may be associated with errors of recall, resulting from cognitive processes such as rationalization and attribution or from memory lapses (Glick et al., 1990). However, the type of information that was obtained, and the time interval the research focused on, necessitated the use of subjects as direct informants. Had subjects' executives been asked to report on the activities, or on technologies that were part of subjects' job, a problem of perceptual distance would emerge. This would probably result in inarticulate and incomplete histories, since the events occurred to others (subjects) and during a time the informants possibly where not around. Because of the explorative character of this investigation, these independent informants were traded off by selecting complete and accurate informants.

Another problem of the method used is right-hand and left-hand censoring of events (Abbott, 1990). The first results from not measuring important events because the data series ends. The impact of this problem for our research is rather unclear. Possibly, observed sequences of events are only part of the real process, with unknown shape and consequences. Left-hand censoring results from the choice of t_0 , which in fact is not controlled by the investigator but by the subject, although t_0 is known to the investigator. Furthermore, the process unfolds in a distinct period of

reality, namely the participation and change of individual research and development employees in contemporary innovative activities. This means that the observed sequences of events can hardly be generalized to other parts of the history of R&D. However, the most important problem of the method used, which relates to the previous problem of left-hand censoring, is that no causal explanations, but only correlative explanations can be expected from this research project. Without use of a control group, consequences of differing sequences of events in a career, may both result from the difference in sequence patterns, as well result from behaviour prior to t_0 . That is, the sequence patterns can be either result or cause of behaviour. This will be taken into consideration when results are being interpreted.

5. Exploring typical sequences/families of sequences

In our data, the question where analysis should start, is whether events typically relate to each other. It relates to typical arrangements of PEJ-combinations, with small intrafamily differences, and substantial interfamily differences. This analysis starts with the measuring of interevent distances, by comparing between subjects, the transitions between subsequent PEJ-combinations. These are then transformed into interevent proximities, by subtraction from constants, which will result in a event proximity matrix. Essentially, such a matrix reflects the proximities between the subjects on one specific point in time. Finally, this matrix can be used as input for analysis of the intersequence distance, in order to assess the effectiveness of the grouping of events into sequences.

Seven typical patterns were determined on the basis of the experience data (E_i), in two organizations (a subset of the data). These patterns are shown in table 1.

Experience pattern	Career pattern description
career 1	limited initial experience without indepth growth during the career
career 2	initial or acquired experience lost during career (decline)
career 3	initial experience not retained but replaced to other areas (switch)
career 4	initial or acquired experience retained without growth on other areas (specialists)
career 5	stormy knowledge growth with limited retention, hand in hand growth and decline across areas
career 6	retention of initial high level experience with growth in other areas as well
career 7	limited initial experience with subsequent indepth growth (growth)

Table 1 Seven experience patterns in R&D.

6. Policy implications.

In our opinion, this research can be used as a vehicle for policy formulation and implementation in a number of areas. As was indicated recently by Bailyn (1991) various hybrid careers should be further developed. One of these concerns the project to project career, which is proceeded by a large proportion of R&D employees. Here, R&D employees are allocated on projects during their career, without moving on a technical ladder or into management. The information that results from our research could be instrumental in this process of project allocation over employees, thereby offering challenging working condition and limiting obsolescence. Our data not only describe the nature of various career tracks, but can be related to performance in innovative activities as well. This way, preferable career tracks could be discerned, in terms of combinations of experience, activities, and technologies. Furthermore, the research indicates the dynamics of innovative

capacity. The management of technology merely rests on the current and future availability of technological resources within the organization. If it is possible to relate this capacity to career management, future innovative capacity may be enhanced.

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Appendix A Measurement of the PEJ combinations

Experience is an element that embodies the level of competence that is attained at the specific time, throughout the complete list of relevant knowledge areas for the employer. This list is produced in a joint effort of the investigator and the employer of the subjects. The actual length of the list varies with the companies and departments involved in the research, (ranging from a number of 27 to 39 areas). For each knowledge area, a competence score is obtained, using a four-points scale, ranging from not competent on the area (0), able to join conversations on the area (1), constructive thinking along with specialists on the area (2), to self-reliant development/accumulation on the area (3). These are the possible observations of table 2.

		t_1	t_2	t_3	t_4	t_5
Knowledge area	1	E_1t_1	E_1t_2	E_1t_3	E_1t_4	E_1t_5
	2	E_2t_1	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	k	E_kt_1	E_kt_1	E_kt_1	E_kt_1	E_kt_1

Table 2. Experience as competence levels across knowledge areas throughout $t_1 \dots t_5$ (values 0 through 3)

The activities of each event refer to the specific work activities the person executes, the time available for them, whether executed in direct or indirect contact with the customer, at t . These activities are made up of development activities and activities related to development work. The technology aspects of the job refer to questions about a Research-Development scale, a complexity scale, a newness of products and processes scale etc.

Appendix B Instructions to subjects

" We ask you to consider your career in periods, and to describe a number of characteristics of your job during these periods. Note that your last period is your present job; your first period was your first job. A career period is defined as a period in your career, characterized by a specific work setting, and tasks you were assigned to. We assume that a complete career can be described in 5 periods. These periods then differ in work content, or appeal on your knowledge and skills. We cannot formulate this more precise; it is up to you to describe the transitions in your career. Note: not of interest are job changes which resulted from organization changes without change of job content or work setting."