Drivers of organizational creativity: a path model of creative climate in pharmaceutical R&D

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A path model of organizational creativity was presented; it conceptualized the influences of information sharing, learning culture, motivation, and networking on creative climate. A structural equation model was fitted to data from the pharmaceutical industry to test the proposed model. The model accounted for 86% of the variance in the *creative climate*-dependent variable. Information sharing had a positive effect on learning culture, which in turn had a positive effect on creative climate, while there were negative direct effects of information sharing on creative climate and on intrinsic motivation. This study suggests that information sharing and intrinsic motivation are important drivers for organizational creativity in a complex R&D environment in the pharmaceutical industry. Implications of the model are discussed.

1. Introduction

Recently, the issue of creativity has gained increased interest as an important organizational resource (e.g. Andriopoulos, 2001). But the concept of creativity remains ambiguous, because the organizational influence has not fully been acknowledged. One important characteristic of organizational creativity is its relation to the access to relevant knowledge and the ability to share scientific information. This paper presents a conceptual framework for organizational creativity; the framework identifies antecedents of organizational creativity as a set of dimensions. These dimensions are creative climate, learning culture, information sharing, motivation, and networking.

Hypotheses are tested using empirical data from a complex R&D environment.

A challenge for all companies is to create an organization that allows activities to be effectively performed, while creativity and innovation are given opportunities to flourish to avoid stagnation (Kanter, 1998; Van de Ven et al., 1999; Van Dijk and Van den Ende, 2002). Recently, the issue of creativity has gained increased interest as an important organizational resource (Ford, 2000; Kazanjian et al., 2000; Williamson, 2001; Mumford et al., 2002). While there is a strong tradition to study creativity as a personal characteristic of individuals (e.g. Scott and Bruce, 1994; Ford and Gioia, 1995; Isaksen, 1987), conditions that promote creative performance in organizations are

still largely unexplored, or contested (Oldham and Cummings, 1996). But in recent research, steps have been taken to understand creativity in an organizational context, using concepts such as *organizational creativity* (e.g. Woodman et al., 1993; Ford, 1996; Clitheroe et al., 1998). This research focuses on a previously uninvestigated area, namely, information sharing within and between organizations. This area is particularly interesting for large research-intensive industries such as the pharmaceutical industry (Dorabje et al., 1998) in which effective access to and exploitation of existing scientific information was identified as one of the most critical factors for achieving productivity (Cardinal, 2001).

By almost any measure, including R&D intensity and use of new scientific concepts, the pharmaceutical industry is a classic high-technology and science-based industry (Pisano, 1997; Santos, 2003). The industry shares many characteristics with other technology-intensive industries, but it has unique features, such as the highly regulatory environment, long development cycles, and a high level of risk and cost in the research process. The pharmaceutical industry has had a long tradition of scientific breakthroughs and innovations (Horrobin, 2002). But today, this industry is wrestling with many issues, some of the most serious being rapidly increasing R&D costs in combination with only small increases in output of the drug discovery process (Schmid and Smith, 2002a). During the last decade, the industry increased its focus on incremental innovation, decreasing time to market and reducing bottlenecks to optimize the patent term of the product (Tranter, 2000). In addition, many pharmaceutical companies have turned to rigorous project and portfolio management to make the research process more effective (Schmid and Smith, 2002b). Despite mergers and acquisitions, increased R&D budgets, and new technological improvements, the industry has not been able to sustain its reputation for producing radical innovations (Horrobin, 2001). Consequently, this resulted in increased focus on how the industry will manage organizational creativity as an organizational capability (e.g. Dollery, 1999; Thompson, 2001).

Many industries are fundamentally altered through the introduction of sophisticated information infrastructures in which information becomes an increasingly important resource (Sampler, 1998). The drive toward globalization has made it crucial for pharmaceutical firms to invest considerable resources in information infrastructures that can fulfill their varied informa-

tion-processing and communication needs (Koretz and Lee, 1998). There are expectations that increased information sharing will affect organizational creativity. But far from being a linear process, use of the information infrastructure is an open-ended endeavour and in many cases, out of control. So we must get deeper insights into how information sharing influences organizational creativity.

Woodman et al. (1993) defined organizational creativity as '... the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system'. (p. 293). They also observed that organizational creativity might be viewed as a subset of the broader construct of organizational innovation, which in turn may be viewed as a subset of the even broader construct organizational change.

Woodman et al. (1993) argued that to understand organizational creativity we must understand how the creative process, the creative product, the creative person, and the creative situation interact with one another. They also proposed that the perspective of interactional psychology provides a useful theoretical base for achieving an integration between traditions of research that focus on (1) *individual creativity* and (2) *organizational research on innovation* (cf. West and Farr, 1990). One basic tenet of the interactionist approach is that human behaviour must be understood as a product of both person and situation. This implies that individual differences in creativity may be partly understood in terms of individual characteristics such as cognitive style, cognitive ability, personality, and motivation. But situational and contextual factors also are important (Woodman and Schoenfeldt, 1989). Similarly, group creativity is a function of individual creative behaviour and situational factors, such as the interaction of individuals within the group, group characteristics, group processes, and contextual influences from the larger organization. Organizational creativity is a function of the creativity of the groups of the organization and of contextual influences from, among other things, organizational culture, resource factors, and the environment of the organization (Woodman et al., 1993). Thus '... the creative output (new products, services, ideas, procedures, and processes) for the entire system stems from the complex mosaic of individual, group, and organizational characteristics and behaviours occurring within the salient situational influences (both creativity constraining and enhancing) at each level of social organization' (Woodman et al.,

1993, p. 298). Based on a review and interpretation of research findings within the interactional perspective, Woodman et al. put forward three propositions and 12 hypotheses to guide further research on organizational creativity. Subsets of these hypotheses were investigated in the present study, and they are explained below.

One of the fundamental problems in investigating organizational creativity is to define and measure the dependent variable. Following Amabile et al. (1996) and Ekvall and Ryhammar (1999), we focus upon perceived *creative climate*. Amabile et al. (1997) reported several important findings from studies based on a self-report instrument ('KEYS: Assessing the Climate for Creativity'), which captures respondents' perceptions of different characteristics of the creative climate of their organization. In this approach, the assumption is that the instrument reveals '. . . the psychological meaning that respondents attach to events in their organizations, their organizational units, and their work groups. So the level at which the source of influence operates is less important than the perceptions themselves and their relation to creativity'. (Amabile et al. 1997, p. 1157). The climate refers to behavioural patterns that emerge on a daily basis in the organizational environment. Individuals in the organization experience, understand, and interpret these patterns. The way in which attitudes, intentions, and behaviours are shaped in the work environment depends a lot on peoples' perceptions of these patterns. This focus on the psychological meaning of the environment agrees with the interactionist theory proposed by Woodman et al. (1993).

Amabile et al. (1997) also demonstrated the construct validity of their measures of creative climate by showing, among other things, that it discriminated between work environments that produce high-creative output and environments that produce less creative work. Using a Swedish instrument similar to 'KEYS', Ekvall (1987, 1996, 1997) established links between perceived creative climate and innovation. And other studies offered empirical support for a relationship between perceived climate and innovation (Paolillo and Brown, 1978; Siegel and Kaemmerer, 1978; Abbey and Dickson, 1983; Bommer and Jalajas, 2002).

Although researchers have learned much about determinants of the creative climate and the consequences and importance of it, there has been comparatively little systematic theory-driven research that focuses on the roles of the traditional determinants, such as goals, leadership styles, and organizational structure in relation to

the growing demands of knowledge sharing in organizations. Initial theorizing (Ekvall, 1987; Woodman et al., 1993; Ford and Oglivie, 1996) suggests that organizational context factors such as autonomy, evaluation forms, incentive programs, and problem formulation influence the creative climate.

But beyond the general consensus that organizational context affects the creative climate, relatively little is known about how information sharing in organizations could transform the creative climate. Specifically, more knowledge is needed about the effects that information sharing may have on the creative climate through two important factors: learning culture and intrinsic motivation.

2. Factors affecting creative climate

2.1. Information sharing and networking

Creativity and innovation is based on information, which makes it reasonable to expect that information sharing at all levels in an organization is important for the creation and successful transfer of corporate knowledge. Woodman et al. (1993, p. 312) cite research, which shows that free exchange of information is crucial for creativity, and they formulated the hypothesis that creative performance is increased by group norms that support open information sharing. They also proposed the hypothesis that at the organizational level, constraints on information and communication have negative effects on creative performance (p. 314).

During the decade that has passed since Woodman et al. formulated these hypotheses, developments in information and communication technology have put information sharing in an even more central position. Information sharing is evolving into a technology of relationships, which facilitates the flow of interaction through computer-based communication networks, groupware, increasingly intelligent agents, knowledge representation and management systems, video-conferencing systems, and the convergence of different forms of traditional media (e.g. Kao, 1996; Weisenfeld et al., 2001; Cooper, 2003). Increasingly, employees can now tap into a host of new stimuli, challenging input, and dissonant opinions that form the raw materials of the creative process. The meaning of information as used here refers to a concept of strategic information that is related to the scientific and or pharmaceutical projects and not primarily operative information related to cost reduction, for example. In addition, we define networks as different types of communica-

tion, social contacts, interaction, and information exchange that occur outside an employee's ordinary line and project organization. The informal nature of networking lies in the fact that such encounters often, or always, took place outside the line and project organization. In addition, these networks were driven by intrinsic motivation, and were predominantly *ad hoc* and short lived. Previous research has shown the importance of social networks for promoting creativity, especially the form of networks called 'weak ties' (Granovetter, 1982). A weak tie, in contrast to a strong tie, is an infrequently occurring interaction that contains little or no contact between individuals. Weak ties are similar to the interactions that occur in the informal networks named above in that the interaction is often between different groups and not within the same group. So informal networks seem to become important entities in which creativity seems to be hidden in an organizational capacity of *connectivity* (Perry-Smith and Shalley, 2002). Thus we hypothesize:

H1a: *There is a positive relationship of information sharing in the organization on its creative climate.*

H1b: *There is a positive relationship of networking in the organization on its creative climate.*

For any organization, culture is a facet of the environment and the basis for potential change (Maton, 2000). Many researchers have acknowledged the need for a culture of learning in an organization – to facilitate organizational learning, and knowledge transfer (e.g. Fiol and Lyles, 1985; Huber, 1991; Aubrey and Cohen, 1995). A learning culture includes beliefs and attitudes that support the systematic and ongoing use of knowledge and information for improvement (Botcheva et al., 2002). Such culture thus encourages experimentation, promotes constructive dissent, learning from mistakes, and promotes an open, continuous dialogue with stakeholders within the company (e.g. Harvey et al., 1998; Botcheva et al., 2002). Cummings and Teng (2003) observed that in a firm with a *learning culture* that '. . . fosters delegating responsibility, tolerating creative mistakes, and providing slack time to work on new ideas. . .' (p. 49), the processes of retaining and nurturing received information will be more effective. We thus hypothesize:

H2: Perceived learning culture mediates the relationship between information sharing and creative climate (i.e. information sharing affects learning culture, which in turn affects the creative climate).

2.2. Effects of information sharing on intrinsic motivation

Information sharing requires self-initiated activities to fully capitalize from the rich pool of codified knowledge. Self-initiated activities are powerful because intrinsic motivation primarily drives them (e.g. Deci and Ryan, 2000; Dhawan et al., 2002). Intrinsic motivation may be defined as the motivation to work on something because it is interesting, involving, exciting, satisfying, or personally challenging. But extrinsic motivation relates to factors in work, which are driven by the desire to attain some goal outside the specific work tasks, such as achieving a promised reward or position or meeting a deadline. It has been observed that when employees are allowed and encouraged to pick and pursue their own projects, their personal interests drive them. Research in a corporate setting has shown that professional interests – rather than espoused theory – motivate people (e.g. Amabile, 1997). It also is a well-established research finding that intrinsic motivation is positively related to creativity (e.g. Woodman et al., 1993; Amabile, 1999). Although information sharing may provide employees with rich cognitive maps that indicate the direction for work, it cannot make them conduct the work as they see fit. Intrinsic motivation, as a driving force for self-initiated activity, is absent. It is believed that knowledge will only be actually used in its optimal location within the organization if employees are matched with projects according to their interests. And their competence must be challenged and developed. In this way, intrinsic motivation and self-initiated activities will enable information sharing initiatives to result in a creative climate (Kim and Lee, 2003). These relations suggest that information sharing is related to intrinsic motivation, which in turn is related to perceived creative climate. Thus, we hypothesize that:

H3: Perceived intrinsic motivation mediates the relationship between information sharing and creative climate (i.e. information sharing affects intrinsic motivation, which in turn affects the creative climate).

3. Method and Data

3.1. Respondents and procedure

The sample consisted of managers and researchers employed at six R&D sites (three in Sweden, two in the UK and one in the US) in AstraZeneca

R&D. They work in two research organizations: Experimental Medicine and Clinical Science. The two types of organizations studied were engaged in applied research within clinical development, which is pivotal for scientific drug development activities. The Experimental Medicine organizations have a key function: transform and validate pre-clinical models for human concept tests on compounds that target new molecular mechanisms. The Clinical Science organizations take the drug projects into larger clinical trials to clarify if the drug has the expected therapeutic effect and dose–effect relationship (i.e. proof of concept). The two organizations were thus heavily involved in the design and evaluation of all clinical research programs to meet medical, ethical, and regulatory standards and commercial demands.

Questionnaires (in English and Swedish) were administered via company e-mail and were completed during normal working hours. Participation was voluntary for all invited employees, and confidentiality of responses was assured. All respondents were told that the data collection was part of a research study on organizational creativity in the company. We received 453 questionnaires, a 64% response rate. The most prevalent age interval was ages 40–49 (37%), and the average tenure in the R&D organization was about 5 years. The sample also had an equal distribution between women and men (49:51%), and a high educational level: 90% had an academic education and 63% had a Ph.D. The proportion of respondents who had managerial roles was 37%. Data were collected from June to October 2002; the process included five reminders.

3.2. Measures

All measures were originally developed for this study except for the Creative Climate Questionnaire instrument. For each measure, respondents assessed their agreement with statements on a seven-point Likert-type scale that was divided into two item categories: strength and frequency. Items referring to strength, e.g. 'To what degree do you experience that the company's stated visions are reflected in the organization's actions?' had a scale with response categories: (1) Not at all, (2) Very little, (3) Relatively little, (4) To some extent, (5) Quite a lot, (6) Very much, and (7) To the highest extent. Items referring to frequency, e.g. 'How often do you feel that people in the company can bring up new ideas and opinions without quickly being criticized?' had response categories: (1) Never, (2) Very infrequently, (3) Relatively

infrequently, (4) Now and then, (5) Relatively frequently, (6) Very frequently, and (7) Always.

As background for developing the questionnaire, we examined the literature on organizational climate for creativity and innovation (Ekvall, 1996), motivation factors (Amabile, 1986; Keeney, 1992; Woodman et al., 1993; Deci and Ryan, 2000), networks (Granovetter, 1982; Bras, 1995), and learning culture (Argyris and Schön, 1996; Ford, 1996). Davenport and Prusak (1998), Dewett and Jones (2001) and Koh (2000) influenced the information category; they emphasize different characteristics of handling, accessing, and sharing different kinds of scientific information. Based on these five categories, a conceptual model was designed to serve as a platform for developing the survey. In the model, creative climate is seen as an endogenous construct or dependent variable, and the other factors are thought as independent variables. In the conceptual model, we anticipated that these independent variables could become dependent variables in subsequent relationships.

Guided by this conceptual model, we created an initial set of 57 items that aimed at being indicative of employees' beliefs and perceptions relevant to the five categories. All items were originally developed except for those in the creative climate category. During different development stages, the questionnaire was piloted on small focus groups of pharmaceutical researchers and managers within the company.

3.2.1. Creative climate. The measure of perceived creative climate was adapted from the 10 dimensions (trust/openness, idea support, freedom, playfulness, debates, dynamism/liveliness, challenge, risk taking, conflicts, and idea time) on Ekvall's (1996) 50-item creative climate instrument. The 10 items were rephrased to capture Ekvall's original dimensions and to fit into the scaling. For example, the item that reflects 'idea support' was rephrased to 'How often do you feel that people in the company can bring up new ideas and opinions without quickly being criticized'.

3.2.2. Information sharing. Originally, this 10-item category covered issues of information sharing and characteristics of information services. The information sharing characteristics consisted of four items that reflect the way in which and the extent to which scientific information (as reports and primary data) is shared within and between projects – and between R&D sites. Information sharing characteristics also covered the degree to

which respondents were motivated to make scientific information available over project boundaries and the degree to which promotion was used to make scientific information available over project boundaries. Simplicity of accessing internal scientific information was also captured.

3.2.3. Networking. The networking category consisted of seven items and covered different characteristics of informal networks. We wanted to capture the frequency of knowledge and idea exchanges within informal networks and the support that these exchanges provide. Items ask how often informal networking occurs within- and between-R&D sites, how often problem-solving and idea generation occurs within informal networks, and if informal networks provide active support.

3.2.4. Learning culture. Originally, this category had 12 items that covered different characteristics of learning culture. Items asked, e.g. about the perceived effectiveness of reusing previous experience and expertise. Other characteristics covered were the extent to which managerial feedback affects project work and the ability to reward new ideas. There also was an ambition to pin-point learning capabilities in projects by addressing, e.g. how often people in projects go beyond their established patterns of action to achieve project goals, to what extent people can constructively question each other's opinions in projects, and to what extent project meetings are oriented toward creating new ideas.

3.2.5. Motivation. This category included items relating to intrinsic motivation; the items were formulated to capture the interest, enjoyment, satisfaction, and challenge of the work. There also were items that measured extrinsic motivation, i.e. defined as motivation for work driven by the desire to attain some goal apart from the work, such as achieving a reward, salary, or position.

Another set of items tentatively assigned to the motivation category consisted of four items that covered different characteristics of what the organization judges the employee on, with special focus on making information available to colleagues and participating in informal networks.

3.3. Analysis strategy

Because the measures used in the present study were newly developed, it was necessary to first investigate if the items measure the hypothesized dimensions and if the hypothesized dimensions are empirically differentiable. Confirmatory factor analysis (CFA) was used to investigate these two questions, using the LISREL 8.5 (Jöreskog and Sörbom, 1996) and AMOS 4.0 (Arbuckle and Wothke, 1999) programs under the STREAMS 2.5 (Gustafsson and Stahl, 2000) modelling environment. CFA has been established as a powerful method for analyzing the dimensional structure of a set of observed variables in terms of latent variables (see, e.g. Bollen, 1989; Kline, 1998; Loehlin, 1998). This step involved estimation and evaluation of a series of models in which no constraints were imposed on the covariances among the latent variables.

Having established an adequate measurement model, the next step of the two-step procedure (Anderson and Gerbing, 1988) involved testing the hypotheses of the study through fitting path models for the relations among the latent variables (see, e.g. Bollen, 1989; Kline, 1998; Loehlin, 1998). These tests involved comparison with the unconstrained CFA model, to test whether models with a hypothesized causal ordering among the latent variables reproduced the unconstrained covariance matrix for the latent variables. Alternative models were also evaluated with respect to model fit and interpretability.

Parameters for all models were estimated with maximum likelihood (ML) methods. The assumption of multivariate normality upon which ML is based is somewhat violated by data generated by the seven-step Likert scales used in the present study, which causes the χ^2-statistic to be overestimated and standard errors of estimated parameters to be underestimated (see e.g. Boomsma and Hoogland, 2001). While correction methods are available to compute robust ML estimates of the χ^2-statistic and the standard error estimates (e.g. Satorra and Bentler, 1994), the statistics were not interpreted in such a formal manner, so applying such corrections was unnecessary.

The χ^2 goodness-of-fit test and goodness-of-fit measures such as the Adjusted Goodness-of-Fit (AGFI), Comparative Fit Index (CFI), Normed Fit Index (NFI), and Non-Normed Fit Index (NNFI) guided evaluation of model fit, but most emphasis was put on the *root mean square error of approximation* (RMSEA) index (see Browne and Cudeck, 1993), which on an absolute scale (1) measures the amount of deviation between model and data and (2) accounts for sample size and model complexity. The RMSEA point estimate and the 90% confidence interval of

the estimate were assessed against the criteria, which for a well-fitting model, the point estimate and the upper limit of the confidence interval should be lower than 0.05. Modification indices (Sörbom, 1989), computed by the LISREL program, were primarily used for diagnosis of sources of model misspecification.

For the final structural model, the total effect of each latent independent variable on each latent-dependent variable was decomposed into direct and indirect effects (see, e.g. Bollen, 1989, pp. 376–389). This is because interpretations that only focus on direct effects expressed by the parameter estimates of the relations between variables in a path model will typically produce incorrect conclusions.

4. Results

According to the Anderson and Gerbing (1988) two-step procedure, we first present the measurement model and then the structural model.

4.1. The measurement model

The CFA model was developed in several steps, with the purposes of testing whether the hypothesized latent variables could be identified empirically, of investigating the measurement characteristics of single items, and of reducing the total number of items. The implemented strategy was essentially that outlined by Jöreskog (1993, p. 314) for generating a CFA model. In the first step, each hypothesized category of items was tested for unidimensionality. In some cases, this resulted in the introduction of new latent variables and in deletion of items. In the next step, different variable sets were combined into a full model, and in the final step, the model was refined through introduction of additional relations between manifest and latent variables.

The successive testing and modification of different models on the same data of course makes it impossible to argue that the goodness-of-fit test for the final model can be evaluated against the χ^2-distribution. This, along with the fact that violations of the assumption of multivariate normality causes the χ^2-statistic to be inflated, suggests that the χ^2-statistic should primarily be used for testing differences in fit between different models. The final CFA model, which was used as the baseline model against which different structural models were compared, had a χ^2-value of 1,093.4, df = 598

($P = 0.00$). The RMSEA index was 0.043 for this model, with a 90% confidence interval between 0.043 and 0.047, which indicates acceptable fit of the model to data. Other indices of fit also showed fit to be acceptable (AGFI = 0.86, CFI = 0.92, NFI = 0.85, NNFI = 0.91).

Out of the 57 items in the instrument, 38 were included in the final model, which comprised seven latent variables. The reason why the final model included seven factors rather than the hypothesized five factors is that the items in the motivation category were found to load on three separate variables: *intrinsic motivation, extrinsic motivation,* and *evaluation and reflection*. The other four hypothesized factors, which were labelled *information sharing, learning culture, networking,* and *creative climate,* related to the manifest variables largely as expected. The model also included covariances among residuals of eight pairs of manifest variables that represent minor sources of item overlap. Standardized factor loadings, along with descriptive item data, are shown in Table 1.

Eight items measured the *information sharing* factor; all dealt with accessing and sharing scientific information. Three items with the highest loadings (0.69–0.63) asked about the extent to which scientific information is shared between and within projects and between R&D sites. A fairly high loading (0.50) was obtained for an item (IS5) that asked about information sharing within projects in the form of reports. Items that asked about frequency of access and ease of access to scientific information had lower loadings (0.24–0.50).

The *learning culture* factor was related to nine items, most of which had high loadings on the factor. The highest loadings (0.69) were observed for one item that asked if the organization is good at rewarding new ideas and another item that asked if the company's stated vision is reflected in its actions. Loadings around 0.6 were observed, among other things, for items that asked about effective use of expertise and previous experience and orientation toward creating new ideas.

Four items measured the *networking* factor; loadings were between 0.54 and 0.73. The item with the highest loading asked about frequency of informal meetings for exchange of knowledge and ideas at the respondent's site. Items that asked about frequency of contact with colleagues at other sites and about frequency of problem solving in informal networks had loadings around 0.65.

Three items measured the *intrinsic motivation* factor; two that asked about happiness and positive involvement in work had very high loadings (0.90). The third item, which asked about motiva-

Table 1. Means, standard deviations, and factor loadings for the items.

	Item no.	Mean	SD	Standard factor loading
Information sharing				
How often is it simple for you to get access to meaningful internal scientific information?	IS1	4.59	1.19	0.36
Do you feel that internal scientific information is/data are available in a user-friendly format?	IS2	4.17	1.19	0.50
How often do you read meaningful scientific information on the company's intranet?	IS3	3.80	1.33	0.24
How often do you have access to good IT tools that you can use to treat scientific information?	IS4	4.14	1.55	0.30
How often do you feel that internal scientific information in the form of reports is shared in projects?	IS5	4.14	1.41	0.50
How often do you feel that internal scientific information in the form of primary data is shared between different projects?	IS6	2.98	1.18	0.69
How often do you experience that internal scientific information is shared between R&D sites to be used within projects?	IS7	2.90	1.15	0.63
To what degree do you experience that the organization is motivated to make scientific information available over project boundaries?	IS8	3.34	1.21	0.67
Learning culture				
How often do you experience that people in projects go beyond their established patterns of action to achieve project goals?	OL1	3.97	1.22	0.39
How often do you experience that the organization is effective at re-using previous experience?	OL2	3.46	1.22	0.58
To what degree do you experience that the organization tries to achieve higher goals than the expected ones?	OL3	4.04	1.34	0.55
Do you feel that the organization uses expertise in the company in an effective enough way?	OL4	3.45	1.19	0.63
How often do you feel that people can constructively question each other's opinions in projects?	OL5	4.38	1.26	0.58
To what degree do you experience that the company's stated visions are reflected in the organization's actions?	OL6	3.89	1.10	0.69
Do you feel that you receive feedback from your managers about how your work affects a project's work as a whole?	OL7	3.79	1.43	0.53
How often do you experience that the meetings you participate in are oriented toward creating new ideas?	OL8	3.49	1.19	0.60
Do you feel that the organization is good at rewarding new ideas?	OL9	3.21	1.18	0.69
Networking				
How often do you meet informally with colleagues and exchange knowledge and ideas at the R&D site where you work?	NW1	3.90	1.37	0.73
How often do you have contact with colleagues outside your ordinary line and project organization at other R&D sites?	NW2	3.02	1.29	0.65
How often do you experience that problem solving occurs in informal networks?	NW3	4.09	1.26	0.64
How often do you experience that good ideas are created in informal networks?	NW4	4.35	1.23	0.54
Do you feel that you have a sufficiently large informal network outside your project and line organization?	NW5	3.76	1.34	0.57
Intrinsic motivation				
To what degree do you feel happiness and satisfaction in your work?	IM1	4.97	1.12	0.89
To what degree do you feel positive involvement in your work?	IM2	5.13	1.15	0.90
To what degree are you motivated by challenges in your work?	IM3	5.43	1.09	0.48
Extrinsic motivation				
To what degree are you motivated by challenges in your work?	IM 3	5.43	1.09	0.35
To what degree are you motivated by salary and promotion opportunities?	EM1	4.67	1.46	0.75
To what degree are you motivated by getting acknowledgement from the organization when you suggest an idea?	EM2	5.04	1.37	0.69
Evaluation and reflection				
To what degree do you feel that communication of information and knowledge to others is a part of what the organization judges you on?	ER1	4.12	1.40	0.72
Do you feel that your participation in informal networks is a part of what the organization judges you on?	ER2	2.92	1.32	0.73
Do you experience that the organization appreciates your making information available to your colleagues?	ER3	3.99	1.38	0.73
How often do you experience that there is a balance between reflection and action in your work?	ER4	3.82	1.21	0.55
Creative climate[1]				
To what degree do you feel that the climate in the company is basically positive and encourages new ideas? *(trust/openness)*	CC1	4.40	1.20	0.82
How often do you feel that people in the company can bring up new ideas and opinions without quickly being criticized? *(idea support)*	CC2	4.45	1.18	0.74
To what degree do you feel that the company allows you to solve problems and take actions that you think are most suitable in a given situation? *(freedom)*	CC3	4.26	1.24	0.69
To what degree do you feel that there is a free atmosphere in the organization, where the seriousness of the task can be mixed with unusual ideas and humour? *(playfulness)*	CC4	4.30	1.33	0.73
How often do you experience that different opinions, ideas, experience, and knowledge can be discussed in projects? *(debates)*	CC5	4.35	1.29	0.66
To what degree do you feel that the organization has a dynamic atmosphere? *(dynamism/liveliness)*	CC6	4.07	1.23	0.77

[1] Items are based upon the CCQ questionnaire (Ekvall, 1996). Keywords in parentheses refer to Ekvall's categorization of the items to different dimensions.

tion from work challenges, had a lower loading (0.48).

Three items measured the *extrinsic motivation* factor; two items with the highest loadings (0.75 and 0.69) asked about motivation through salary and promotion and through acknowledgement from the organization. The third item, which asked about motivation through work challenges (0.35), loaded on intrinsic motivation as well. This item thus reflects both intrinsic and extrinsic motivation, which may be because it can be interpreted differently by different respondents. This could be a reason for excluding the item. However, since the other items define the two factors in a clear-cut manner the item was retained.

Four items measured the *evaluation and reflection* factor, three of which had quite high loadings (0.72–0.73). These items asked about the extent to which participation in informal networks and information sharing are characteristics on which the organization judges the individual.

Six items measured the creative climate factor; all items had substantial loadings (0.66–0.82) on the factor. The items with the highest loadings asked about openness to new ideas in the organization in which there is a dynamic, playful atmosphere and if there is freedom to come up with unusual ideas. To reduce overlap with learning culture, four items that related to challenge, risk-taking, conflict, and idea time were removed.

Table 2 shows the correlations among the seven factors of the CFA model.

The correlations among the factors are ML estimates from the CFA model, and these are correlations between error-free latent variables. The diagonal of the matrix also presents internal-consistency coefficients of the reliability of unity weighted sums of the scores on the items, and although some of the latent variables comprise as few as three items, the α-coefficients vary between 0.69 and 0.87.

The creative climate factor has positive correlations with all the other factors, the highest corre-

lations were with learning culture (0.85) and intrinsic motivation (0.70). While these correlations are high, discriminant validity tests have showed that the factors are distinct.

The variables that will be treated as independent variables in the path model also have positive correlations with one another. The highest correlation was observed for information sharing and learning culture (0.72).

In conclusion, the pattern of loadings and correlations in the CFA model generally supported the hypothesized factors, even though a more differentiated set of motivation factors had to be included.

4.2. The structural model

In the next step of modelling, path models were fitted to test the proposed model. Because the hypotheses do not explicitly specify the relations among all the factors, and because some unexpected relations were found, a sequence of models was fitted. Selection criteria for the final model were (1) fit to data and (2) interpretability of the estimated relations.

The path model had a test-statistic of $\chi^2 = 1,097.90$, df $= 605$. A χ^2 difference test between this model and the CFA model is a test of the hypothesis that the more restrictive path model reproduced the correlations among the latent variables estimated by the CFA model. The difference test yielded $\Delta\chi^2 = 4.50$, Δdf $= 7$, $P < 0.73$, so we cannot reject the hypothesis that the more restrictive path model correctly reproduced the correlations among the latent variables. The path model accounted for 86.3% of the variance in the creative climate-dependent variable. Figure 1 shows the model.

The path model included three independent latent variables (networking, information sharing, and evaluation and reflection) among which no direction of relationship was assumed. These variables were thus allowed to be freely correlated;

Table 2. Correlations among the factors of the measurement model.

Variable	1.	2.	3.	4.	5.	6.	7.
1. Information sharing	*(0.74)*						
2. Learning culture	0.72	*(0.82)*					
3. Networking	0.22	0.27	*(0.77)*				
4. Evaluation and reflection	0.51	0.66	0.34	*(0.76)*			
5. Intrinsic motivation	0.27	0.53	0.23	0.48	*(0.84)*		
6. Extrinsic motivation	0.20	0.24	0.22	0.42	0.37	*(0.69)*	
7. Creative climate	0.46	0.85	0.26	0.65	0.70	0.43	*(0.87)*

$n = 453$. Values in parentheses are Cronbach α's.

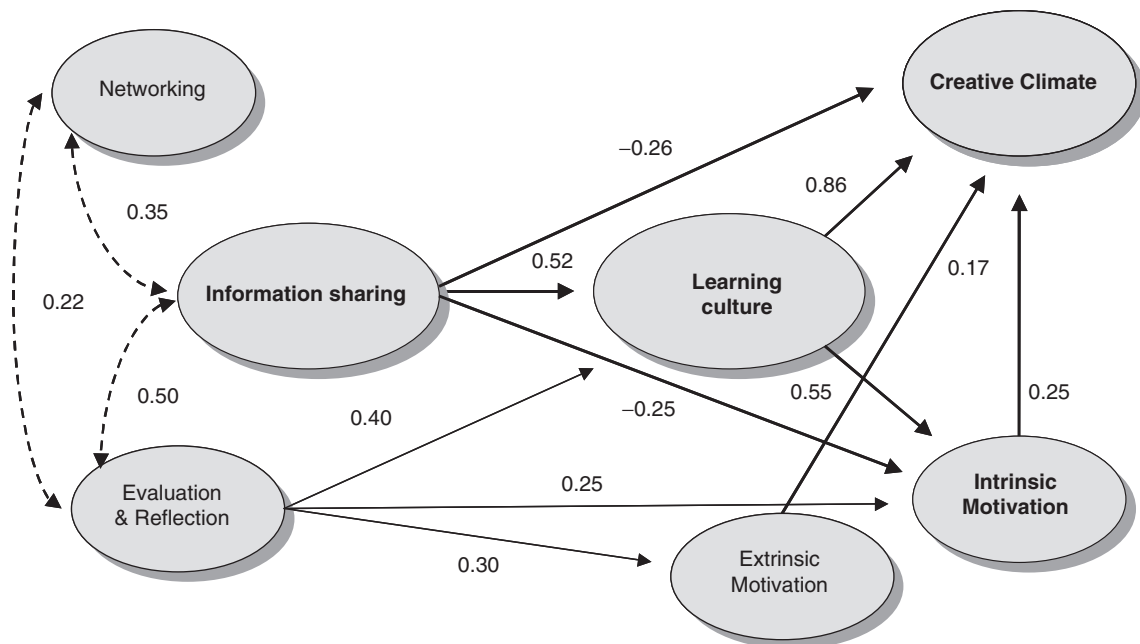*Mats Sundgren, Elof Dimenäs, Jan-Eric Gustafsson and Marcus Selart*

Figure 1. Path model for relations among the latent variables[a]. [a]Path coefficients are standardized partial regression coefficients estimated by maximum likelihood. Ellipses represent latent variables (constructs). Unidirectional arrows express direct effects, and bi-directional curved arrows represent correlations between latent variables. All path coefficients are significant at $P < 0.01$ level. $N = 453$.

positive correlations that range between 0.22 and 0.50 were observed. According to the model, networking had no direct effect on any other latent variable. Evaluation and reflection had positive relations with learning culture, and with both intrinsic motivation and extrinsic motivation. Information sharing had a quite strong positive direct effect (0.52) on learning culture and relatively strong negative direct effects (around -0.25) on intrinsic motivation and creative climate.

The model specified three latent variables to be both dependent and independent variables (learning culture, extrinsic motivation and intrinsic motivation) or mediating factors. Learning culture had a very strong direct effect of 0.86 on creative climate and a strong effect of 0.55 on intrinsic motivation. The two motivation factors both had positive direct effects on creative climate, the effect being somewhat stronger for intrinsic motivation (0.25) than for extrinsic motivation (0.17).

The pattern of direct effects revealed by the path model seems to provide somewhat mixed evidence for the study's hypotheses. According to Hypothesis 1a, we expected a positive relationship between information sharing and creative climate, but we observed a negative direct effect! But note that we cannot interpret the pattern of influences among the variables unless we consider the indir-

ect effects – and the total effects – which are the sum of the direct and the indirect effects. Table 3 shows the effect decomposition.

According to the results in Table 3, there was a positive total effect (0.20) from information sharing on creative climate, and this result supports Hypothesis 1a. The reason why this was not evident from the path diagram was that the total effect is a function of the negative direct effect (-0.26) and a strong positive indirect effect (0.46). The indirect effect of information sharing on creative climate, in turn, consisted of three, specific, indirect effects: (1) an effect via learning culture ($0.52 \times 0.86 = 0.45$); (2) an effect via intrinsic motivation ($-0.25 \times 0.25 = -0.06$); and an effect via learning culture and intrinsic motivation ($0.52 \times 0.55 \times 0.25 = 0.07$). So although matters seem more complicated than originally envisaged, the results of the path model support Hypothesis 1a.

According to Hypothesis 1b, we expected a positive effect of networking on creative climate. But according to the path model, there was no effect from the networking factor on any other latent variable. It may be observed that the CFA model estimated a correlation of 0.26 between networking and creative climate, so had the other factors not been included in the model, this would have been the estimate of the total effect. But in the presence of information sharing and evalua-

Table 3. Effect decomposition for the path model.

Independent variable/ dependent variables	Effect		
	Direct	Indirect	Total
Evaluation and reflection			
Learning culture	0.40	–	
Extrinsic motivation	0.43	–	0.43
Intrinsic motivation	0.25	0.22	0.47
Creative climate	–	0.53	0.53
Information sharing			
Learning culture	0.52	–	0.52
Extrinsic motivation	–	–	–
Intrinsic motivation	−2.5	0.28	0.04
Creative climate	−0.26	0.46	0.20
Learning culture			
Intrinsic motivation	0.55	–	0.55
Creative climate	0.86	0.14	1.00
Extrinsic motivation			
Creative climate	0.17	–	0.17
Intrinsic motivation			
Creative climate	0.25	–	0.25

Note: n = 453. All direct and indirect effects are significant at P < 0.01 level.

tion and reflection, with which networking was correlated, no effect could be seen. Further research will be needed to clarify the relations between networking, information sharing, and evaluation and reflection.

According to Hypothesis 2, we expected a positive effect from information sharing on learning culture. Results of the path model supported this hypothesis – there was a strong direct effect from information sharing on learning culture.

Hypothesis 3 proposes that there should be a positive effect from information sharing on intrinsic motivation. But the path model showed no total effect from information sharing on intrinsic motivation, because a positive indirect effect via learning culture (0.28) was balanced by a negative direct effect (−0.25). So results of the path model do not support Hypothesis 3.

Some other results also deserve comment. Learning culture is a central factor in the model, and this factor related very strongly indeed to creative climate. The total effect of learning culture on creative climate was 1.0; see Table 3. The total effect was because of a strong direct effect (0.86) and to a weaker indirect effect (0.14) via intrinsic motivation.

The results indicate that information sharing has a positive effect on the perceived creative climate at the organizational level through the positive effects on learning culture but negative effects at the individual level through negative effects on intrinsic motivation and on the perception of creative climate.

5. Discussion

This study developed and tested a model of organizational creativity in which information sharing, networking, learning culture, and intrinsic motivation were hypothesized to affect the perceived creative climate in pharmaceutical R&D. We found information sharing, learning culture, intrinsic motivation, and extrinsic motivation to be significantly related to perceived creative climate and that the hypothesized model explained 86% of the variance in creative climate. Although our study design precluded making interferences about causality for all included dimensions, this is a substantial finding – given the limited empirical development in this area to date.

According to the model, the direct relationship of information sharing on the perceived creative climate was negative, which seems to contradict Hypothesis 1. But note that the total effect of information sharing on creative climate is positive and that there is potential to further increase the effect on the creative climate by minimizing the negative direct effect from information sharing on creative climate and intrinsic motivation.

There may be several explanations for these negative effects. The individual within the organization might perceive information sharing as (1) an activity that is costly; (2) a threat to individual identity and recognition; and (3) hindered by competition between projects internally and between sites. Furthermore, this study's respondents are highly independent pharmaceutical researchers who have close relationships with scientific data and information, which also greatly affects their identities and careers. This may cause the negative effects of information sharing on perceived creative climate and on intrinsic motivation to be stronger in a research organization, such as the present one, than in other areas such as the telecom or engineering industries. Further research should be conducted to better understand the negative effects of information sharing and to determine the generalizability of the findings of the present study.

The direct effect of intrinsic motivation on creative climate is in line with previous research (Amabile, 1997). A somewhat weaker but significant direct effect from extrinsic motivation on the creative climate was also found. Previous research indicated that some types of extrinsic motivation can be detrimental to creativity if they involve controlling factors and are incompatible with intrinsic motives (Amabile et al., 1996). This is probably not the case within the organization

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studied here, which offers considerable amounts of freedom.

Our model does not support the hypothesis that there is a positive relationship from networking in the organization on the organization's creative climate. Naturally, this should not be interpreted as proof that networking is not important, because there may be several methodological reasons why we failed to demonstrate effects of networking on the organization's creative climate. Items that measured individual perceptions of networking – rather than organizational structures – might not efficiently capture networking. In the model, networking was treated as an independent variable that is freely correlated with information sharing. This implies that we are investigating effects of networking, while controlling for the level of information sharing. In future research, the relationship between networking and information sharing should be studied in greater detail.

5.1. Limitations

This study's results are of course subject to several limitations. First, the research model integrates research streams across five different perspectives, thereby providing a relatively simplified and obviously not complete perspective of the literature on organizational creativity. As Casson (1981, p. 15) states, the complexities inherent in seeking to develop conceptual integrations 'mean that the theorist must tread a careful path between oversimplification on the one hand, and a preoccupation with minor detail on the other. Some theorists are over-ambitious and range too widely to do justice to any one characteristic of their subject'. While attempts were made to avoid such oversimplification, the comprehensiveness of the model necessarily simplifies reality.

The methodology used also suffers from the obvious limitation that it attempts to capture such an extremely complex social construction as an organization with a highly simplified and constrained model formulated in terms of linear relations among attributes of the organization and the individual. However, while such a model cannot claim to represent how the organization actually functions it serves the purpose of being an analytical tool for investigating empirically which relations hold and which do not hold. Such empirical findings stimulate further thinking and debate.

The methodology also suffers from the more specific limitation that it treats a multi-level problem that involves both organizational and individual aspects at the individual level only. In doing so we follow the tradition established by Amabile (1997) and Ekvall and Ryhammar (1999), and others, and in the Introductory section we have argued that the Woodman et al. (1993) interactionist theory provides a theoretical rationale for this. It would, however, be desirable to use observational and analytical methods that allow simultaneous investigation of organizational and individual aspects. Multi-level extensions of the SEM-technique now are available (e.g. Muthén, 1994; Scott and Bruce, 1994), which could be applied to data from individuals in multiple organizations or organizational units. This is an important task for future research.

Our constructs could have been measured in other ways, and it is important to discuss limitations of the measures used. For the information-sharing concept, Kolekofski and Heminger (2003) propose that it matters a lot whether employees focus on beliefs and attitudes toward networking or whether they focus on intentions to share information. Research findings from applied social psychology (Ajzen, 1991) indicate that intention is a much better predictor of actual behavior than is attitude. Because most information-sharing items do not address general attitudes, we feel that our operationalization of the concept is not sensitive to validity criticism based on attitude-behaviour discrepancy. Most of our items on information sharing do not measure intentions but rather actual experiences and habits. From this perspective, we fail to operationalize the concept in line with the prescriptions made by leading theories of planned behavior (Ajzen, 1991). Still, there is also social psychological research, which reveals that both experiences and habits qualify as valid predictors of behavior.

As for the network concept, results from Perry-Smith and Shalley (2002) reveal that a distinction may be made between static and dynamic social network concepts. It is argued that weaker ties are generally but not always beneficial for creativity and that there are network positions that facilitate and constrain creative work. When focusing on our operationalization of the network concept, it may be noted that we did not explicitly make a distinction between weak and strong network ties. But most of our items that measure networking are directed toward informal networks and hence may be regarded as measures of weak ties. From this perspective, it seems difficult to argue that our operationalization of the concept may explain why networking did not have a significant impact on creative climate in the model.

When it comes to the dependent variable, our study has a limitation. Although earlier creative-climate research substantially supports the positive correlation between creative climate and producing creative outcomes in organizations, there is a gap between creative climate and creative action. In our study, we have not included a variable that reflects creative outcomes, which in our case represent large-scale, long-duration, multidisciplinary pharmaceutical projects. These projects often run more than 10 years and are the result of a complex interaction and contribution of several disciplines in which creative processes are highly relevant. So a pharmaceutical product launch (i.e. a new drug application) is not the only valid outcome of a pharmaceutical project. A proposal for further research would be to investigate several valid outcome variables to reflect the creative outcome of these projects.

From a managerial perspective, the study invites new questions about managing organizational creativity that prompts further debate. In the case of the pharmaceutical industry, scientific information is essential and is the backbone of organizational creativity. But compartmentalization, or what Tranter (2000) calls 'silos' in large pharmaceutical R&D workflows, projects, and in various disciplines, makes information exchange complicated. By changing the organizational culture to become more *information service oriented* new modes of thinking and association patterns may be developed by reusing and exploiting the organization's entire information capital. Another proposition would be to change management evaluation principles, which are now primarily focused on extrinsic motivation, to include more support for information sharing, informal networks, intrinsic motivation, and also promoting new skills in R&D (e.g. researchers' ability to share narratives on how research, innovation, and creativity materialize in daily pharmaceutical research activities).

6. Conclusions

This study suggests that information sharing, intrinsic motivation, and learning climate are important drivers for organizational creativity in pharmaceutical R&D. The study confirms the hypothesis of the central role of learning culture and its relation to information sharing and intrinsic motivation. Thus to develop an understanding of organizational creativity, it is central to adopt a strategy that – besides the technical infrastructure – also considers the environment of information sharing and learning culture. The negative relationships between creative climate and information sharing and intrinsic motivation clearly represent hurdles that the organization must overcome. The study also has potential to reveal new relationships and perspectives relevant to understand organizational creativity and to yield important managerial implications.

Acknowledgement

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