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Gloria Volkmann

Johannes Putzke

Oliver Posegga

Kai Fischbach

Detlef Schoder

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Gloria Volkmann[1], Johannes Putzke[1], Oliver Posegga[2], Kai Fischbach[2], and Detlef Schoder[1]

[1] Universität zu Köln, Seminar für Wirtschaftsinformatik und Informationsmanagement, Köln, Germany
{volkmann,putzke,schoder}@wim.uni-koeln.de
[2] Otto-Friedrich-Universität Bamberg, Lehrstuhl für Wirtschaftsinformatik insbes. Soziale Netzwerke, Bamberg, Germany
{oliver.posegga,kai.fischbach}@uni-bamberg.de

Abstract. Organizations increasingly rely on group-based organizational structures to manage uncertain environments. However, at the group level there is still a limited understanding of how boundary-spanning activities should be managed to increase group performance. In this paper, we propose "out-group-tie centralization" as a concept that refers to the variation in the group members' network ties to other social actors who are not members of the group itself. When the out-group-tie centralization is low, no group member enjoys substantially more ties to other social actors outside the group than does any other group member. A panel analysis with 120 work groups from a medium-size German bank over a 12-month period reveals a reversed u-shaped relationship between out-group-tie centralization and group performance. However, the results indicate no association between the density of a work group communication network and that group's performance.

Keywords: social network analysis, work group performance, boundary spanning

1 Introduction

Today's business environment has become more complex, subject to rapid changes, and uncertain as knowledge economies and greater global competition increase. In growing numbers, organizations have responded to this erratic and complex environment with group-based organizational structures that decentralize decision making and allow them to react more quickly and innovatively [1-2]. Increased task complexity associated with knowledge work and flatter work structures created by group-based structures lead to an increase in interdependence between work groups. Because of this, work groups are increasingly responsible for coordinating and performing complex cross-functional tasks and bridging organizational work groups to create and transfer valuable resources of knowledge and know-how [3]. In the literature, establishing these out-group-ties with other work groups and managing these cross-

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group interactions are often referred to as team boundary spanning [3-5]. This can assist an organization's work groups in meeting performance goals and task objectives [5] because the information and resources gained externally can be used internally to develop strategies and coordinate and complete work tasks. By engaging in boundary-spanning activities, work groups face the challenge of effectively integrating the external environment and transmitting external information and knowledge back into the work group itself, as well as effectively managing the internal work group environment [6]. Internal work group network structures are essential for effectively disseminating to group members information that already exists within the group as well as information obtained externally through boundary spanning [3-5]. Work groups must always balance potentially competing demands and objectives of internal and external group processes [7] and face choices about how to allocate limited attentional resources across various efforts [8].

From a social network perspective, work groups and these challenges can be represented as a network of relational ties established between various groups and within those groups between various group members to carry out these tasks [9]. This has prompted research on work groups and their network structures to analyze the impact of internal and external work group structures and their effect on work group performance outcomes, as well as to analyze which structures help work groups manage competing internal and external demands and therefore influence group performance positively. Prior research has shown that internal and external work group structures have both positive and negative consequences and that those consequences are further affected by contingencies in the task environment, such as the degree of exploration or exploitation inherent in the work tasks [5], [10-16]. However, no clear picture has yet emerged regarding which group structures are most beneficial for the internal work group management, that is, how boundary spanning is best managed and distributed within the group and which internal work group network structure allows a group to perform best. More attention is needed to examine – at a finer-grained level – how member boundary spanning is combined at the group level (e.g., the use of a single focal boundary spanner vs. shared boundary-spanning responsibility across all members, or something in between) [5] and whether a high or moderately dense internal work group network structure is better for work group performance.

Thus, the purpose of this study is to refine the understanding of both internal and external work group structures that are beneficial for the internal work group management. Therefore this study examines work groups performing predominantly exploitative tasks and analyzes which internal group network structures influence work group performance positively, while at the same time examining how boundary spanning activities are best managed at the group level by analyzing which internal distribution structure of boundary spanning ties influences group performance positively. Building on prior research, this study argues that there is a positive linear relationship between work group performance and work group density that results from the creation of a beneficial work atmosphere and group spirit and fast and flexible information diffusion within the group. Furthermore, this study argues that there is a reversed u-shaped relationship between out-group-tie centralization and group performance. At a moderate level of out-group-tie centralization, externally gained resources and infor-

mation can be disseminated quickly and efficiently to other group members, but at a higher level of out-group-tie centralization, boundary-spanning group members may become overstrained and a bottleneck may emerge that makes it difficult to transmit externally available resources and information efficiently to the rest of the group.

Results of an analysis of 120 work groups (performing predominantly exploitative work tasks) from a medium-size German bank over a 12-month period reveal no statistically relevant relationship between work group density and group performance. However, they show a reversed u-shaped relationship between out-group-tie centralization and group performance. Thus, this study contributes to existing literature by confirming the importance of the internal work group management of external work group ties as well as by suggesting that a moderate centralization (i.e., distribution) of out-group interaction among group members benefits the group performance of work groups involved in predominantly exploitative tasks.

The paper is structured as follows. We highlight the theoretical background of this research in section 2. We then develop two research hypotheses in section 3. Section 4 illustrates the method used for hypothesis testing. Section 5 provides the results. Finally, section 6 discusses our results and their theoretical and managerial implications, highlights some research limitations, and points out directions for further research.

2 Theoretical Background

In the social network analysis approach, an organization can be conceptualized as a network in which work groups are nodes that interact with each other. Such a representation of an organization makes abundantly clear that an organization's overall success depends on the success of its work groups. Work groups in an organization, as well as the organization itself, are multilevel constructs. Each work group comprises a network of its members and is simultaneously embedded in the network of all work groups in the organization. Hence, the success of a work group is affected by its external ties to other work groups, because the structure of the interconnectedness of work groups in an organizational network enhances or constrains the access of work groups to resources that are both necessary and valued in meeting performance goals and task objectives [9]. Further, the success of the work groups is affected by the structure of their internal ties, that is, network ties within the work groups. Internal group structures affect the work atmosphere and group spirit and thereby the inclination of group members to share information, help each other, and refrain from opportunistic behavior. In addition, internal group structures affect the speed and flexibility with which information diffuses within a group and how effective a group allocates its attentional resources to balance competing internal and external demands [3-5], [17].

Reagans and Zuckerman [10] found that organizational work groups with denser internal networks achieved a higher level of productivity than those with sparse internal networks. Hansen, Podolny, and Pfeffer [16] found that work teams with exploratory work tasks benefited from a network structure with many strong and nonredundant ties, whereas work groups pursuing tasks that exploited existing expertise

took less time to complete their projects if they had a network composed of weakly tied contacts that were moderately interconnected. In contrast, Sparrow and his colleagues [11] did not find that the density of internal group structures affect work group performance, but did find a negative relationship between work group network centralization and work group performance. In line with Reagans and Zuckerman [10], Mehra and his colleagues [14] found that the networks of high-performance work groups exhibit a higher internal density than those of low-performing work groups, and that work group leaders' network ties with peers and higher-level managers in an organization had a positive effect on work group performance. Furthermore Reagans, Zuckerman, and McEvily [12] found that work groups with a dense internal network structure and a large external range finished projects more quickly. In contrast, Oh and his colleagues [13] found that work groups performed best that had a moderately dense internal network structure and bridging ties to many other groups and formal leaders.

As the findings of previous research show, findings are inconsistent with respect to which forms of internal work group network structure allow a group to perform best. It is not absolutely clear whether a high- or moderately dense internal work group network structure is better for work group performance.

Moreover, the findings of Hansen and colleagues [16] show that the context in which those structures appear is highly relevant, because whether the tasks performed of a group are predominantly explorative – involving highly tacit knowledge – or predominantly exploitative –involving highly explicit knowledge – affects which kind of internal work group network structures allow a group to perform best. They identify exploitative tasks as, for example, daily work, routine work, continuous improvement, increasing production efficiency, and so on [16]. Therefore, much of the knowledge involved in exploitative tasks is likely to be explicit, because the expertise required is already available and the problem, possible solutions, and causal mechanisms among the parameters involved in the task are known [16]. Groups and group members benefit from obtaining existing, complementary knowledge through their network that avoids duplication of effort and, typically, group members know well when and how frequently they need to consult contacts to obtain needed and valuable knowledge [16]. Thus, exploitative tasks can often be split easily into a number of subtasks that can be completed by individual group members. In contrast, exploratory tasks involve problems that are novel to a group and its members and entail, for example, innovation, experimentation, one-time decisions, radical change, and so on [16]. Knowledge involved in exploratory tasks is likely to be tacit, which means it is difficult to articulate or can be acquired only through experience; further, the problem, solutions, and parameters involved in the task are often unknown [16]. Groups benefit from obtaining new ideas and large amount of knowledge through their network and may need to brainstorm the problems, discuss ideas, and exchange views often but irregularly [16]. Thus, exploratory tasks cannot be split easily into clearly defined subtasks that can be completed by individual group members. The entire groups may often need to develop and work on solutions together. Due to these differences in the types of tasks and the differences in the associated requirements of

interaction and exchange, the kind of group structures that are beneficial or disadvantageous for group performance differ according to the types of tasks.[16].

Previous research also has contradicting opinions and results regarding how boundary spanning is managed and distributed best within the group (e.g.,. shared boundary-spanning responsibility across all members vs. the use of a single focal boundary spanner, or something in between). On the one hand, Oh and his colleagues [15] argue that groups whose external relationships are distributed among more members within the group gain more and greater benefits from those relationships than groups in which those relationships are concentrated in a smaller number of group members. In addition, Marrone and colleagues [18] found that individual boundary spanning behavior did result in individual experience of role stress, but with increased boundary spanning at the work group level and with every work group member engaging in boundary spanning behavior, individual role stress was significantly diminished. One the other hand, Sherman and Keller [19] suggested, "When the volume of direct contact between two interdependent units increases with multiple personnel communicating, coordination problems can develop if a common point of contact does not exist in each unit […]. Boundary-spanning roles would minimize coordination problems caused by the increasing complexity of the network of communications spanning two interdependent units" (p. 248). Moreover, Davison and colleagues [20] found that groups that enact differentiated group roles as a mechanism to achieve coordination consistently outperform work groups that act like one large, undifferentiated group in which everyone is interacting with everyone else.

In sum, prior research has suggested the need to refine the understanding of how structural properties of internal and external work group network relations affect group performance while simultaneously considering whether the tasks performed are predominantly exploitative or exploratory and whether the knowledge required is predominantly tacit or explicit. In this study, we try to refine the understanding of how the structural properties of internal and external work group network relations at the group level (i.e., within the group) contribute to group performance for groups predominantly engaged in exploitative tasks. In doing so, this study focuses on the informal social networks in the workplace in and between work groups at the work group level, because the informal network makes work processes visual and shows how work in an organization is actually done. It shows how work groups and their members actually interact – giving and receiving needed resources such as information, know-how, feedback on progress, and support from key external parties – to accomplish tasks. [9].

Due to these particularities, an organization's informal social network relies not only on direct face-to-face communication, but also on permissive information system components (e.g., videoconferences, teleconferences, telephone, e- mail) designed to support more unstructured group interactions. Hence, this study focuses on the informal network of work groups in the organization built by social relations constructed of interaction ties of the work group members gathered via permissive information system components.

3 Hypotheses

3.1 Work Group Network Density

The density of a work group network is the intensity of interaction between all group members and is equivalent to the proportion of all possible interaction ties in a group that are actually present. This means the more ties each group member enjoys with other group members, the greater the density of the group-network. Previous research on groups in organizational systems suggests that the density of a group-network is associated with group performance (e.g. [11], [13]).

There are several theoretical reasons for a positive association between density and group performance. For example, Sparrowe and colleagues [11] argue that in groups with a dense interaction structure, one can expect a greater agreement on expectations, a stronger sense of accountability and thereby stronger reciprocity norms, greater awareness of each other's expertise, greater trust, and greater cooperation than in a group lacking such a dense interaction structure. Intense interaction among group members makes each group member aware of other group members' roles and responsibilities in the group and thereby also pinpoints the expectations and accountabilities of each group member. Hence, visibility of opportunistic behavior increases and thereby restricts opportunistic behavior within the group [11]. By counteracting opportunistic behavior, increased visibility and accountability also facilitate mutual trust and cooperation within a group [17]. Group members are more willing to share information and help each other because they know other members of the group will act alike and help and information given will ultimately be returned by another member of the group [13]. Moreover, interaction and exchange of information among group members develops, increases, and calibrates the awareness of each other's expertise. Therefore, one may have to seek out fewer group members to get required and sought-after information and help. This, in turn, leads to fewer chances of misinformation and less added workload for group members, because knowing how to get help and information directly reduces the need to go through the leader or other group members to get expertise and information [21]. Hence, in summary we hypothesize:

Hypothesis H1: The higher the density of a work group communication network, the higher the performance of the group.

3.2 Out-Group-Tie Centralization

"Out-Group-Tie Centralization" within a work group refers to the variation in the group members' network ties to other social actors who are not members of the group itself. When the variation in the number of network ties per group member is low, no group member enjoys substantially more ties to social actors outside the group than does any other group member. In contrast, when the variation in the number of network ties per group member is high, some members have proportionately more ties to social actors who are not members of the group itself.

Research on work group performance indicates that boundary-spanning activities are critical drivers of team performance because groups bridge otherwise diverse and

disconnected parties through out-group-ties with other groups as they pursue information transfer, knowledge creation, outside support, and feedback [3- 4], [13], [16]. Therefore, these groups may receive more diverse information, learn faster about developments in the organization, and be able to access a broad base of political support [12-13]. To be effective, work groups will need to manage group boundary-spanning interactions. Oh and colleagues [15] argue that an efficient way to manage group boundary spanning is by encouraging all group members to form network ties with members of other groups, because if a group's "external ties are more concentrated in a small number of group members, or just one group member, the remaining group members might become insulated from diverse information and opinions available externally. This insulation of the group from its environment invites more homogeneity of ideas and, thus, reduces its overall decision-making capacity" (p. 574). However, establishing and maintaining interaction ties across groups imposes additional demands on the group members above and beyond their own task-work and within-group interactions. Boundary spanning across groups is challenging and stressful for individuals because they face simultaneous and often conflicting pressures that require considerable time and effort [7-8], [18]. Therefore, given limited time, attention, and resources, groups need to develop and manage out-group-ties to other subgroups in the most efficient way. Because the volume of direct contact between two interdependent groups increases with multiple group members communicating, the development of coordination problems is more likely when all members of a group are interacting in an uncoordinated manner with all members of other groups in the organization. Therefore, information processing requirements argue for the restriction of direct interaction among each and every person [19]. Instead, a select number of group members will need to adopt integrating roles and maintain and manage out-group-ties for the entire group [20]. This will enable work groups to access and integrate various resources from other work groups quickly without being overwhelmed by having to manage excessive across-group interactions [22]. Hence, we hypothesize:

Hypothesis H2: There is an inverted u-shaped relationship between out-group-tie centralization and group performance.

4 Method

4.1 Sample

To test the proposed hypotheses, we analyzed a data set provided by a medium-size German bank with approximately 4,000 employees and some 389 work groups. The data set included the formal group membership of each employee, as well as all emails (without content) sent or received by bank employees (n=3,653) during 2010. In total, the email archive comprised 4,950,801 emails belonging to 142,858 dyads. Bank privacy regulations stipulated that our analyses be conducted anonymously. Therefore, the organization assigned a unique, randomly generated number to each employee and work group before handing the dataset to the researchers. Furthermore,

the organization excluded from the analysis work groups with fewer than 4 employees to prevent identification of employees through a unique combination of their attributes (e.g., gender and age), membership in such a small work group, the structure of their interactions within their work group, and the structure of interaction of their small work group with other work groups. This excluded 188 work groups from the analysis. From the remaining 201 groups, we identified 121 groups as profit centers with direct market contact ("sales groups"), for which the bank could provide us with comparable performance measures (see section 4.2). However, for the final analysis we had to exclude a single work group that was a severe outlier, because its performance was approximately 10 times the performance of the other work groups.

The 120 work groups in the final sample ranged in size from 4 to 66 members; the average group size was 15.12 members. The average age of the employees in the sample was 37.66 years, and 43.7 percent of employees were men. The tasks performed by these 120 sales groups in the final sample are exploitative tasks that involve banking services such as construction financing for private households, high-net-worth individuals, and companies; retail banking services for private households; private banking services for high-net-worth individuals; corporate banking services for companies; and funding and financial services for start-ups and new ventures. These tasks can be completed directly by an individual group member or can be split into subtasks that can be completed by an individual group member.

4.2 Measures

Dependent Variable.

Group Performance. The bank assesses the performance of its sales work groups based on the degree to which they achieve their contribution margin targets. These data were provided on a monthly level. Since these performance indicators are highly confidential, the bank rescaled them on a scale between 0 and 1 before providing them to us.

Independent Variables.

Work Group Network Density. The density of a group network g refers to the intensity of directed interaction between all n_g group members. It is calculated by dividing the number of the existing relational ties between all group members of a group e_g by the number of all possible relational ties between all group members of a group n_g (n_g -1):

$$density(g) = \frac{e_g}{n_g (n_g - 1)}$$

Out-Group-Tie Centralization. Graph centralizations are based on the differences between the centrality of the most central actors and the centrality of all others [23]. The out-group-tie centralization $C_o(g)$ of a work group g describes the variation in the group members' network ties to other social actors who are not members of the group

itself. It is calculated as the sum of the differences between the largest observed number out-group-ties $c_o(p^*)$ for group member p* and the number of out-group-ties $c_o(p_i)$ observed for each other actor p_i:

$$C_O(g) = \sum_{i=1}^{n_g} [c_o(p^*) - c_o(p_i)]$$

Dividing with the theoretical maximum sum of differences normalizes the centralization. This maximum value results for work groups whose ng members each share ties with all other ($n-n_g$) members of the organization, where n is the total number of actors in the network. Thus, the normalized out-group-tie centralization is shown as:

$$C'_O(g) = \frac{\sum_{i=1}^{n_g} [c_o(p^*) - c_o(p_i)]}{n_g(n - n_g)}$$

Gender proportion. As previous research has shown that teams with a higher percentage of women have a higher collective intelligence and hence should perform better [24], we added the percentage of women in a work group as a control variable.

5 Results

For hypotheses testing, we estimated a series of panel data models (e.g., [24]) in R (v. 3.0.2) using the packages lme4 (v. 1.1-7) and plm (v. 1.4-0). Panel data models can be estimated when data are collected from the same subjects over multiple periods. As illustrated above, our balanced panel comprised 1440 observations (i.e., 12 months of observations for each of the 120 work groups). Table 2 shows the results for a model that includes fixed effects for only the 120 work groups. "Fixed effects" for the 120 work groups mean that we estimated a model with the following functional form

$$\begin{aligned} Group\ Performance_{it} &= \beta_0 + \beta_1 gender\ proportion_{it} + \beta_2 density_{it} \\ &+ \beta_3 out\text{-}group\text{-}tie\ centralization^2_{it} \\ &+ \beta_4 out\text{-}group\text{-}tie\ centralization_{it} \\ &+ \sum_{n=2}^{N} \gamma_n work\ group\ dummy_n + u_{it} \end{aligned}$$

In this context, "work-group-dummies" refer to dummy variables added for each work group to allow for considering unobserved heterogeneity between work groups. Table 3 shows the results for a model with fixed effects for the 120 work groups as well as for the 12 months. That means the model had the following functional form

$$
\begin{aligned}
&Group\ Performance_{it} \\
&\quad = \beta_0 + \beta_1 gender\ proportion_{it} + \beta_2 density_{it} \\
&\quad + \beta_3 out\text{-}group\text{-}tie\ centralization^2{}_{it} \\
&\quad + \beta_4 out\text{-}group\text{-}tie\ centralization_{it} \\
&\quad + \sum_{n=2}^{N} \gamma_n work\ group\ dummy_n + \sum_{m=2}^{M} \gamma_n month\ dummy_m \\
&\quad + u_{it}
\end{aligned}
$$

"Month dummies" refer to dummy variables added for each of the twelve month. Before the estimation, the variables "work group network density," "out-group-tie centralization," and "out-group-tie centralization²" were standardized to avoid multi-collinearity. Table 1 shows the Pearson correlation coefficients for the independent variables.

Table 1. Correlation matrix

	(1)	(2)	(3)	(4)
(1) Gender proportion	1.0000			
(2) Density	-0.1188	1.0000		
(3) Out-group-tie centralization	0.1023	-0.2217	1.0000	
(4) Out-group-tie centralization²	0.0635	-0.0585	0.6291	1.0000

Table 2. Model 1

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	0.0173946	0.0029085	5.981	2.86e-09	***
Gender proportion	0.0606160	0.0085822	7.063	2.63e-12	***
Density (standardized)	0.0001120	0.0003102	0.361	0.718093	
Out-group-tie centralization²	-0.0002791	0.0001251	-2.230	0.025886	*
Out-group-tie centralization	0.0009485	0.0003105	3.055	0.002299	**
Work group Dummies		Yes			
Month Dummies		No			
R^2		0.2272			
Adjusted R^2		0.1556			
F(122, 1317)		3.173***			

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

Tables 2 and 3 illustrate our results. Dummy variables are not included in the tables due to space restrictions. As evident from Tables 2 and 3, the control variable "gender proportion" was found to have a significant effect on group performance at a .001 level of significance in both models. Contrary to our expectations, Hypothesis H1 was not supported by the data. Hence, we cannot conclude that the higher the density of a work group communication network, the higher the performance of that group.

Table 3. Model 2

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	0.0177184	0.0028905	6.130	1.16e-09	***
Gender proportion	0.0606361	0.0084070	7.213	9.27e-13	***
Density (standardized)	0.0002430	0.0003090	0.786	0.431859	
Out-group-tie centralization²	-0.0002157	0.0001238	-1.741	0.081848	†
Out-group-tie centralization	0.0006555	0.0003099	2.115	0.034630	*
Work group dummies			Yes		
Month Dummies			Yes		
R^2			0.2649		
Adjusted R^2			0.1901		
F(133, 1306)			3.539***		

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

However, the squared term for out-group tie centralization was found to be negative and statistically significant in both models (p<.05 and p<.1). Hence, Hypothesis H2 is supported and we can conclude that there is an inverted u-shaped relationship between out-group-tie centralization and group performance.

6 Discussion

6.1 Theoretical and Managerial Implications

This study aims to help clarify which internal group network structures help work groups perform best, and how boundary spanning activities are best managed at the group level, by examining the internal distribution and structure of boundary spanning ties that influence group performance positively. For that purpose, we hypothesized and tested whether a high density of the internal work group communication network influences work group performance positively. We also hypothesized and tested whether there is an inverted u-shaped relationship between out-group-tie centralization and group performance to support our proposed work group boundary spanning management approach, which states that the best way to manage boundary spanning at the work group level is to assign boundary spanning tasks to a small number of selected group members suited to the task.

Our data did not support Hypothesis H1, perhaps explainable by the fact that there may also be negative effects on performance from high-grade dense interaction structures within a group. Higher levels of density in the interaction structure increase the likelihood that group members approach peak levels, where their workload capacity begins to reach overload from increased communication due to many communication partners and reciprocal helping activities [16], [22], [25]. Capacity overload, particularly over extended time, increases stress and reduces group member motivation, thus negatively affecting their performance and, by extension, overall group performance

[26]. Furthermore, at high levels of density, individual behavior may become determined or controlled by the system, constraining individual autonomy to cooperate or partake in reciprocal helping activities as individuals see fit and are able to handle, thereby in turn having a negative effect on group performance [22]. This is because increased visibility and accountability due to intense interaction among group members indirectly create group behavior norms and ensure that these norms are maintained [17]. While this may restrict opportunistic behavior and therefore affect group performance positively, as mentioned above, these group behavior norms may also force group members to engage in cooperation and reciprocal helping activities even if those group members are already operating at full capacity or if their capacity is strained. The increased communication and workload may create or increase capacity overload, which in turn increases stress, reduces motivation, and impairs the performance of individual group members [26], in turn having the same effect on overall group performance. Moreover, constraining individual autonomy to interact, cooperate, engage in reciprocal helping activities, and do work as the individual sees fit also reduces the satisfaction and motivation of group member's by inhibiting the gratification that accompanies culturally supported needs for autonomy, recognition, and achievement [25]; in turn, it may reduce individual performance and, by extension, overall group performance. In addition, highly dense in-group interaction structures can lead to a very strong work group-community feeling with strong positive in-group biases and negative out-group biases, therefore limiting or preventing the absorption and elaboration of alternative information generated external to the group and even perhaps leading to strong norms against associating with actors who are not members of the group [13], [15]. This is because work groups with strong positive in-group biases and negative out-group biases tend to develop an "us-versus-them" mentality [22]. Interactions with other groups are then more likely to be perceived as interfering, and information exchanges across groups that would otherwise be perceived as providing helpful feedback or constructive criticism may be seen instead as attacks [22]. These biases limit access to and absorption of new and innovative information from outside the group, creating a tendency for the information inside the group to be homogeneous and redundant [27].

In summary, one might argue for a reversed u-shaped relationship between density and performance. In other words, increased density should have a positive relationship with performance to a certain point, at which the positive aspects of a high density (see the research hypothesis development of H1) are reversed by the negative aspects highlighted in the last paragraphs.

Therefore, we reestimated Model 1, adding a squared density effect to the equation (see Table 4). However, we found neither the squared density effect nor the ordinary density effect to be statistically significant at a .1 level of significance. Hence, we also cannot conclude that there is a reversed u-shaped relationship between density and performance. This fact can be also illustrated by a scatter plot that depicts the association between density and group performance (see Fig. 1). Apparently, there is no (linear or reversed u-shaped) relationship between density and group performance.

Of more theoretical and managerial relevance are our results regarding Hypothesis H2. The hypothesis tests supported a reversed u-shaped relationship between out-

group-tie centralization and group performance (compare also Model 3 in Table 4). These findings indicate that work groups should pay attention not only to managing their interactions within the group, but that it is necessary as well to manage actively the ties to out-group members. An organization should not encourage its group members to leave out-group interactions to a central person within the team, nor should it encourage all group members to have an equal level of out-group interactions. Rather, a medium level of variance in the amount of out-group interaction among group members is beneficial for work group performance.

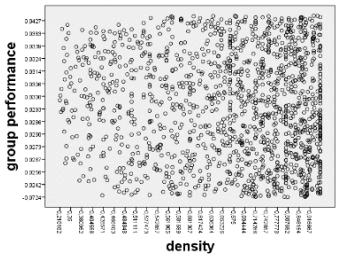

Fig. 1. Scatter plot group performance / density

Table 4. Model 3

	Estimate	*Std. Error*	*t value*	*Pr(>|t|)*	
Intercept	1.670e-02	2.947e-03	5.665	1.80e-08	***
Gender proportion	6.201e-02	8.633e-03	7.183	1.14e-12	***
Density²	2.824e-04	1.956e-04	1.443	0.149131	
Density	9.116e-05	3.104e-04	0.294	0.769082	
Out-group-tie centralization²	-2.871e-04	1.252e-04	-2.294	0.021970	*
Out-group-tie centralization	9.751e-04	3.109e-04	3.136	0.001750	**
Work Group Dummies		Yes			
Month Dummies		No			
R^2		0.2284			
Adjusted R^2		0.1563			
F(123, 1316)		3.167***			

† p < .1; * p < 0.05; ** p < 0.01; *** p < 0.001

6.2 Limitations and Future Research

Of course, as with any empirical study, ours is subject to some limitations that could be seen as affecting the rigor and relevance. First, in the panel data model we did not consider any time lags between the independent variables and the dependent variable. For example, we assumed that a higher density would cause a higher performance in the same period. However, it could be that the positive density effects pay off only later. Hence, future research should examine lagged effects from the density on the performance of a work group. Second, the examined effects were rather small despite

their statistical significance. Hence, future research should replicate our findings using different samples. Third, in this study we merely found a correlation between outgroup-tie centralization and the performance of work groups. Correlation in and of itself does not imply causation. Hence, future research should test Hypothesis H2 with different methods that allow testing for causation (e.g., controlled experiments). Fourth, to construct the informal network with its social relation ties, we used the occurrence of email communication between the employees of the organization analyzed. One could argue that using the email network as a proxy for the informal network is invalid, since some employees may have informal contact with each other without exchanging emails. Consequently, some of the informal social ties between employees and work groups may be missing in our data set – suggesting that one should construct the informal network via a questionnaire. However, using the email network as a proxy for the informal communication network also has some advantages over a questionnaire – especially that email interactions between individuals and groups can be gathered automatically. This helps avoid the social desirability bias, memory effects, and the Hawthorne effect, as well as transcription errors that occur when the adjacency matrix (which is the aggregate of the information provided by the respondents) is entered manually into evaluation software [28]. However, we suggest future research should reexamine our findings using other means for collecting the informal network. We do not consider these limitations to void our results, so long as we remain aware of them as we draw conclusions. In fact, they suggest some future research that examines the association between informal interaction networks and the performance of work groups. It is our hope that our research will assist others in conducting these types of studies and form the basis for substantial future research into the relationship between informal interaction networks and the performance of work groups.

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