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Network Ties and Transactive Memory Systems: Leadership as an Enabler

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Structured Abstract

Purpose This paper studies the relationship between network ties (NT) and transactive memory systems (TMS), observed through three dimensions—specialization (TMSS), credibility (TMSCR), and coordination (TMSCO)—in the presence of leadership (LDR) as a moderating variable, in university research-and-development (R&D) groups.

Design/methodology/approach The data are composed of 257 university R&D groups. To confirm the hypotheses, we use multiple linear regression analysis with a moderating effect.

Findings The conclusions show that the relationships between NT and two of the three dimensions of TMS (TMSCR and TMSCO) are significant when LDR is included as a moderating variable. Although the effect of TMSS is positive, it is not significant. Including the interaction element enables better explanation of two of the dimensions of TMS in the sector analyzed. Thus, LDR is perfectly applicable to the university R&D environment.

Research limitations/implications This research has several limitations that suggest further possibilities for empirical research. The limitations include the cross-sectional nature of the research and the judgment of a single manager as the basis of the perception analyzed for each group.

Practical implications We provide several implications for R&D practitioners. The results of this study could be validated in other universities in other geographic areas, enabling better generalization and applicability of the results. The results described may serve as a guide for group leaders of university R&D. This research helps us to see the importance of leadership in forming internal research networks that help researchers to perform common projects in order to obtain better results in the group. Thus, the groups provided better results to society.

Originality/value No studies have tested the moderating effect of LDR in university R&D empirically. Our results provide information to fill this gap and demonstrate the applicability of leadership as a key element in the organization, improvement, and cohesion of R&D groups.

Keywords: Leadership, transactive memory system, network ties, R&D, groups.

Article Classification: Research paper

1. Introduction

The use and popularity of networks among researchers in the social sciences has intensified in recent years. Prior studies by sociologists, anthropologists, and economists use the theory of network ties (NT) to demonstrate the nature and effect of interaction and exchange that take place between individuals (Katz et al., 2004). The concept of network dates to the 1930s and is an element belonging to social capital. It is strongly related to frequency of interaction and communication between team members (Chiu et al., 2006). Further, connections developed in the network are seen as interpersonal cohesion characterized by social interaction (Huang, 2009). Significant conceptual, empirical, and technical advances have thus created great interest in analyzing networks (Wölfer et al., 2015).

Social scientists increasingly recognize the potential of analyzing networks, since they enrich explanation of human behavior, specifically for the science of groups. In this case, analysis of networks has become a valuable tool for investigating both groups and mechanisms related to intergroup behavior (Wölfer et al., 2015). Our study focuses on this theory, starting from the assumption that groups are totally connected subsets of a population in which their members are clearly defined (Katz et al., 2004).

The past decade has experienced an increase in studies that treat networks in small groups (Katz et al., 2004). There is still little theoretical corpus, however, that links these small groups to networks (Lungeanu and Contractor, 2015). The phenomenon related to research in networks of small groups has been neglected and is currently being revived (Börner et al., 2010; Lungeanu and Contractor, 2015). This fact—along with the high level of creativity and uncertainty on the topic, characteristic of new scholarly disciplines (Lungeanu and Contractor, 2015)—explains why research on networks in small groups is fast emerging as a field of study (Lazer and Katz, 2003; Lungeanu and Contractor, 2015).

To study the behavior of these small groups, our research combines NT and transactive memory systems (TMS) with leadership (LDR). The TMS is a system that explains how individual memory can expand with the aid of other members who compose the system (Ren and Argote, 2011), where members collaborate and coordinate with each other constantly (Jones, Wuchty, and Uzi, 2008; Wuchty et al., 2007). Currently, studies of TMS are very important and are widely analyzed because they permit study of work groups from a complex perspective that tackles integration of knowledge and professional abilities (Liao et al., 2015; Bih et al., 2015; Heavey and Simsek, 2015). TMS is closely associated with work groups in the literature and is used frequently to study the effectiveness of groups' cognitive mechanisms. Leaders, in turn, are the people responsible for ensuring that networks function correctly. Networks are essentially work groups. They need leadership to function because leadership helps with the cohesion and organization of groups (Zaccaro et al., 2001; Morgeson et al., 2010). Formation of TMS also benefits greatly from having leaders, since successful functioning of this process depends on the formation of transactive memory structures. TMS originates in the ability to connect each of the elements of knowledge that others have within the system (Wegner et al., 1985; Ren and Argote, 2011; Hood et al., 2014), and leaders are precisely the people who should help to connect the different elements of knowledge within their network (Wölfer et al., 2015).

Networks have been linked to other variables, such as knowledge transfer, innovation, and entrepreneurship (Lungeanu and Contractor, 2015; Abrams et al., 2003; Fernández et al., 2015). Our study analyzes TMS from a new perspective, that of networks (Wölfer et al., 2015), which, linked to LDR, enriches explanation of human behavior, a current topic of interest for the science of groups (Westaby et al., 2014; Wölfer et al., 2015). The connection of NT to TMS and LDR as variables moderating the relationship has not been studied in previous research, and our study contributes new information on this theoretical and empirical gap.

To analyze these relationships, our study focuses on the context of university R&D. Studying NT in R&D groups in the university context is relevant, since R&D groups are tied into internal networks to carry out different university research projects. It is thus a core for analysis that corresponds perfectly to the theory of network ties in small groups. The researcher represents a specific type of network worker (Dimitrova et al., 2013), one who collaborates explicitly and exclusively with the other members in order to create knowledge. Leaders, on the other hand, play an important role in these groups because they interact constantly with other members of the group, which can have positive effects on the group's organization, cohesion, and performance. This research topic has much to offer to small researchers in a group, as it increases the results of work (innovation) and helps to attenuate and even eliminate performing work alone (Saporito, 2013; Singh and Fleming, 2010; Lungeanu and Contractor, 2015). For these reasons, this study takes small university R&D groups as its unit of analysis. Based on the foregoing, the main goal of this paper is to study how LDR moderates the relationship between NT and TMS in university R&D groups.

This study seeks to contribute to literature and practice in a twofold line of research. First, the study considers a current trend, network research, from an innovative perspective (Lungeanu and Contractor, 2015), using LDR as moderating variable in its relation to TMS. We thus contribute information to the literature on LDR, investigating whether leaders can provide important and unique benefits, beyond the ties themselves created by the members of a group connected in a network, to create TMS. Second, we contribute empirical results that help to increase knowledge on the theory of networks in small groups and how to improve management of them.

This article is structured as follows: After this introduction, we present a literature review; we then describe the research methodology and present the data analysis. Finally, we discuss the results obtained and present the main conclusions, limitations, and future lines of research.

2. Literature review and hypothesis development

2.1 Connection between NT and TMS

The construct NT has been analyzed in the literature, both theoretically and empirically, since it is currently considered a relevant factor in the development of competitive advantages (Taylor and Greve, 2006; Uzzi and Spiro, 2005; Wuchty, Jones, and Uzzi, 2007). NT can be understood as the real set of connections of any kind among a set of individuals (Mitchell, 1973). This connection can provide privileged information and access to opportunities, and permit people in the network to obtain resources. The nodes of the network may be individuals, groups, organizations, or societies (Katz et al., 2004; Wölfer et al., 2015) and can be developed both internally (Doerr et al., 2004; Chen et al., 2008; Huang et al., 2009) and externally (Acquaah, 2007; Zeng et al., 2010). In this study, we tackle the interactions of the network internally, since work in a network is an increasingly frequent way of organizing work within organizations (Chen et al., 2012) and of making better use of knowledge, being more effective, and performing more creative tasks (Monge and Contratista, 2003; Wu, Lin, Aral, and Brynjolfsson, 2009; Burt, 2010).

Network theory throws into relief the importance of human relationships, the interdependencies that are created in work, and a better explanation of the different behavior of network members beyond the personal characteristics of each individual (Borgatti and Halgina, 2011). We thus relate NT to TMS in university R&D groups. TMS is known to be a variable associated closely with work groups in the literature (Liao et al., 2012). TMS is used to study the effectiveness of groups' cognitive mechanisms and can be defined as the cooperative cooperation of work that occurs between team members to learn, record, and communicate relevant knowledge about the group and its different facets (Hollingshead, 2001). TMS thus encompasses the emerging cognitive state that occurs at group level, in which the different members have distributed memories and knowledge that are transformed into group property when the person enables the other members of the group to take advantage of their memories and knowledge effectively, giving rise to a system of group metaknowledge (Kozlowski and Klein, 2000).

TMS can be observed through its dimensions (Akgun et al., 2005), such as specialization, credibility, and coordination (Moreland, 1999). Multidimensional rather than one-dimensional study of TMS is much more interesting because it examines the dimensions and their effects in greater depth than is achieved by studying each dimension separately (Akgun et al., 2005; Huang, 2009). The dimension Specialization (TMSS) is related to the team members' capability to understand who has specialized knowledge (Lewis, 2003; Akgun et al., 2005). The dimension Credibility (TMSCR) is the capability to trust reliability of the knowledge, and the dimension Coordination (TMSCO) is the organization of knowledge differentiated effectively (Lewis, 2003; Akgun et al., 2005; Liao et al., 2012; Hood et al., 2014).

All of these dimensions can be fostered by NT, since the evolution of networks and network connections has significant implications for the creation of opportunities in groups, a prerequisite for TMS. Given the possible relationship between the variables, we decided to study the relationship of NT and TMS from three dimensions: First, NT and specialization in the TMS (TMSS); second, NT and credibility (TMSCR); and third, coordination in the TMS (TMSCO).

TMSS is one of the most important dimensions in TMS and is being recognized as a highly relevant cognitive factor in the research on group performance (West and Markiewicz, 2004). This dimension of the TMS refers to the advantage of relying on members of the group who have specialized or very specific knowledge about something (Zhong et al., 2012). It represents the collective consciousness that all know who count on the knowledge of the other team members, knowledge that can be used to support performance of a specific task (Heavey and Simsek, 2015). This dimension of the TMS encourages development of the group in general and is key to value creation (Grant, 1996). NT aid in creating the TMSS because they contain people who specialize in certain topics. NT can create distributed memory, in which each member is responsible for certain knowledge, which, when coordinated with the other members, complements and strengthens the others, decreasing the problem that one individual must know everything (Huang and Huang, 2007). NT provide techniques for identifying and exploring specialized knowledge, promoting future interaction within the small group (Katz et al., 2004). They also help the team members to stay connected and enable some functions that construct ties in the work, characteristics that are also positively related to TMSS in teams (Zhong et al., 2012). We therefore propose the following hypothesis:

H1: NT is positively related to TMSE in R&D groups.

Second, TMSCR is associated with trust in the reliability of others' knowledge (Chen and Leung, 2010). Credibility indicates the reliability and beliefs of the members of a team concerning their colleagues' competences (Kanawattanachai and Yoo, 2007; Zhong et al., 2012; Liao et al., 2012; Hood et al., 2014). When team members trust in the capabilities and competences of each member, they will feel more comfortable accepting suggestions and sharing information (Zhong et al., 2012). Constant communication will thus occur when members work while tied into the network, facilitating tasks and knowledge of each individual. Such work will lead to formation of trust based on cognition (Butler Jr. and Cantrell, 1994; Kanawattanachai and Yoo, 2007). It will help team members to judge the competence of each member (Liu et al., 2014), facilitating the creation of TMSCR. Working while tied into the network provides evidence of reliability to one's colleagues, which promotes credibility within a team (Liu et al., 2014). We therefore propose the following hypothesis:

H2: NT is positively related to TMSCR in R&D groups.

Finally, TMSCO helps team members to understand each other and to work in a coordinated, organized way, organizing knowledge effectively (Chen and Leung, 2010). Coordination is the organization of knowledge differentiated effectively (Lewis, 2003; Liao et al., 2012; Hood et al., 2014). It has been shown that close social relationships between team members are beneficial for improving coordination and cooperation (Chen and Peng; Liu et al., 2014) and for enabling people to work comfortably (Guimera, Uzi, Spiro, and Amaral, 2005; Taylor and Greve, 2006). There are many benefits to applying the network perspective to small groups, such as, for example, that being tied into a network helps researchers to integrate and coordinate themselves much better (Katz et al., 2004). Further, problems of coordination occur when the members do not manage to recover the exact, useful knowledge of other members, when their knowledge is perceived negatively, or when difficulties arise in integrating their respective knowledge with that of the other members—characteristics of deficient network ties (Hood et al., 2014). We therefore propose the following hypothesis:

H3: NT is positively related to TMSCO in R&D groups.

2.2 Effects of leadership on the relationship between NT and TMS

Recently, the literature has stressed that interactions with leaders in the project work can contribute to the way an individual gives meaning to his/her work and in making workers give the best of themselves, providing much greater value to the result (Wrzesniewski and Dutton, 2001; Pratt and Ashforth, 2003; Wrzesniewski et al., 2003; Peng et al., 2015). LDR is seen as a key factor for enabling a group to function in an optimal way (Cotterill, 2013).

As the use of teams has increased in organizations, research has begun to focus on the role of leaders in achieving the team's success (Morgeson et al., 2010). Leadership in teams is thus a cutting-edge topic in research and shows significant advances (Day et al., 2006). This study will focus on the theory of functional leadership, which proposes that the role of leadership is to improve what is not being managed well according to the needs of the group (McGrath, 1962). This concept fits perfectly with NT, as the network needs functional leaders who make it stronger and who fulfill the functions of monitoring, boundary management, facing challenges, organization of tasks, problem solving, organization of resources, and support for the social climate in which work is done (Morgeson et al., 2010). These characteristics help to develop a much denser network. Thus, combining NT with LDR positively encourages TMS from the perspective of specialization, credibility, and coordination. Our results provide information to fill this gap and demonstrate the applicability of leadership as a key element in the organization, improvement, and cohesion of R&D groups.

Leaders can help to identify and share information on the limitations and opportunities within the team and to provide a general view of the relationships that can arise to develop the different tasks in a group (Venkataraman et al., 2014). Leaders are perfectly positioned to interact regularly with team members (Oh et al., 2006), as well as to help connect them (Graen et al., 1972). Leaders thus have a strategic position that permits them to recognize and understand the challenges and opportunities that arise (Venkataramani et al., 2014). Leaders also help to transmit important information, developing a collective sense in the group (Weick, 1995; Zohar and Hofmann, 2012; Peng et al., 2015) and make top-down efforts to transmit their intentions concerning work routines and work policies (Peng et al., 2015). Group leaders are thus in a unique and privileged position to help to strengthen the relation between NT and TMSS, TMSCR, and TMSCO, since their position permits them to participate often in information exchanges with diverse employees, organize work in the groups, and coordinate with other leaders (Peng et al., 2015). Further, leaders act as integrating elements inside the group (Oh et al., 2006), since they resolve concerns, problems, and resources and contribute to ensuring that group members achieve the objectives (Venkataramani et al., 2014). We therefore propose the following hypothesis, shown in Figure 1.

H4: LDR positively moderates the effect of NT on its relationship with TMSS in R&D groups.

H5: LDR positively moderates the effect of NT on its relationship with TMSCR in R&D groups.

H6: LDR positively moderates the effect of NT on its relationship with TMSCO in R&D groups.

Insert Figure 1

3. Methods

3.1 Sample and procedures for data collection

The sample was composed of Spanish university R&D groups belonging to all disciplines, regardless of the groups' size, region, age, or field of knowledge. The data were gathered using a questionnaire. We chose Spanish university R&D groups as the unit of analysis due to the importance of studying their internal processes (Minguillo and Thelwall, 2015). These groups have begun to acquire a crucial role in universities as generators of knowledge through research (Bayona et al., 2002) and are currently considered one of the fundamental pillars of university prestige (Minguillo and Thelwall, 2015). Further, their members (researchers) are organized into work groups to develop R&D activity, suiting the objective of our study perfectly.

We chose 3000 groups through simple random sampling and contacted the principal investigator of the group. We received 260 responses but rejected two because they were incomplete and one because it was received after the deadline. We thus obtained 257 questionnaires, giving a response rate of 8.57% and a sampling error taking an infinite population of 6.1% with a confidence level of 95%. Since the response rate is relatively low, it is useful to analyze non-response bias. To do this, we performed an ANOVA, which showed no statistically significant differences between respondents and non-respondents in demographic variables. It is also important to take into account that the surveys were addressed only to team leaders and that surveys of company owners generally yield much lower response rates (Gielnik et al., 2012; Zacher et al., 2012; Zacher and Rosing, 2015).

3.2 Measurement scales. Reliability and validity

To ensure the content validity of the scales used, we performed an exhaustive literature analysis, which provided deep knowledge of what was to be measured (Hair et al., 2004). In the case of LDR, the scale used was adapted from Samson and Terziovski (1999). This scale was used by Prajogo and Zohal (2006) for R&D environments and is thus perfectly suited to the goals of our study. For TMS, we adapted the scale proposed by Akgun et al. (2005), used in a prior study to measure the construct specifically in R&D groups (Huang, 2009). Finally, NT ties were measured by adapting the scale proposed by Chiu et al. (2006). Table 1 shows the scales used.

Insert Table 1

All scales were accompanied by a seven-category Likert scale (1=disagree completely and 7=agree completely). To guarantee their one-dimensionality, we performed an exploratory factor analysis with the statistical software SPSS 15.0. The study of internal consistency of the scales (see Table 2) showed an Alpha Cronbach ($\alpha = 0.7$) higher than the minimum recommended value of 0.7 and the measurements of extracted variance greater than 0.5 (Nunnally, 1978). During the validation process, we eliminated items TMSS2 and TMSS4. The results of the confirmatory analysis (see Table 3) show that all indicators fulfill the three necessary requirements for convergent validity. All factor loadings are significant ($t>1.96$; $p<0.05$) and higher than 0.4, and the value for individual reliability (R2) is over 50% (Hulland, 1999)1. The analyses performed affirm that the scales used fulfill the conditions of one-dimensionality, reliability, and validity.

Insert table 2 and 3

4. Data Analysis and Results

4.1 Data analysis

To analyze the data, we used the multiple linear regression technique with a moderating effect, supported by the program SPSS 15.0. The moderating variable was leadership. Tables 4 and 5 show the descriptive statistics of the sample and the correlation matrix, respectively.

Insert table 4 and 5

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[1] Items TMSS1 and TMSCR1 show values of R^2 very close to 0.5 and were retained to preserve the scales' content validity. Similar studies show values above 0.4 to be acceptable (e.g., Kim et al., 2012).

We performed tests to determine whether the data were optimal, fulfilling the requirements for linearity, normality, homoskedasticity, and multicollinearity (Hair et al., 2004). In using the interaction terms in the analysis, we found them to be highly correlated, causing multicollinearity and unstable estimations. We therefore focused on the direct terms, subtracting the mean of each variable from the values for each observation (Aiken and West, 1991). Table 6 shows the results, which demonstrate that there are no problems of multicollinearity among the independent variables. The tolerance values (close to 1, threshold set at 0 -1) and the variance inflation factor (VIF) (close to 1, threshold set at 10) are within the appropriate levels. We must propose that tolerance is merely the degree to which each independent variable is explained by other independent variables, and the VIF is the inverse of the tolerance (Hair et al., 2004).

Insert table 6

4.2 Multiple regression analysis with moderating effect

We proposed three regression models, accompanied by the control variables, income, and number of members in the group. These were not significant, and the results were valid for any Spanish university R&D group, without importing the number of members in the team or its income level. First, we studied the relationship between NT and TMSS, using LDR as a moderating variable. Second, we analyzed the relation between NT and TMSCR, also using LDR as a moderating variable. Finally, we studied the relation between NT and TMSCO, also using leadership as a moderating variable.

Table 7 shows the results of the first regression analysis performed. Hypothesis 1 proposes that NT has a positive and significant relationship to TMSS with ß=0.196; ***p<0.01. TMSS is thus explained linearly as 6.2% for a confidence level of 99%, enabling us to accept H1. In contrast, introducing the moderating effect of LDR (NT X LDR) increases the value of R2, but not significantly (ß=0. 021), leading us not to accept H4, which proposed that LDR moderated the relation between NT and TMSS.

Insert table 7

Table 8 shows the results of estimating the regression model for LDR as a variable moderating the relationship between NT and TMSCR. The direct relation of NT to TMSCR is positive and significant (ß=0.194***; p<0.01), explaining 7.5% of the dependent variable, which leads us to accept H2. We see that introducing the moderating element in the equation (Model 4) causes a change in the value of R2. This value increases by 0.026 for a confidence level of 99%, explaining 21.4% of TMSCR. That is, the interaction between NT and LDR is positively and significantly related to TMSCR (ß=0.378***; p<0.01), supporting H5. The total effect of NT on TMSCR thus increases positively with introduction of the interaction element, since it is represented by both effects (0.106 + 0.378 x LDR).

Insert table 8

Finally, Table 9 shows the results of estimating the regression model for LDR as a variable moderating the relationship between NT and TMSCO. In this case, NT also explains TMSCO directly and significantly (ß=0.241***; p<0.01) and explains the dependent variables at 8.1%, leading us to accept H3. We see that introducing the moderating element in the equation causes a change in the value of R2. That is, LDR moderates the relation between NT and TMSCO (ß=0.568***; p<0.01). The value of R2 thus increases by 0.012 for a confidence level of 99%, explaining 31.7% of the TMSCO, supporting H6. The total effect of NT on TMSCO increases positively with introduction of the interaction element, which is represented by both the linear and the moderating effect (0.104 + 0.568 x LDR).

Insert table 9

5. Discussion

In this study, we have investigated the relationship between NT and TMS, analyzed from the dimensions of TMSS, TMSCR, and TMSCO (H1, H2, H3), using LDR as a moderating variable (H4, H5, H6), in Spanish university R&D groups. Analyzing TMS from a multidimensional perspective permits us to obtain individualized conclusions for each dimension. This type of analysis contributes more information to the variable and to analysis of group work. Specifically, for the field of group research, our results represent a valuable focus for studying the internal relations of groups and their processes. We have focused on group theory, specifically on the theory of internal networks for small groups, due to the lack of research analyzing small networks as teamwork (Börner et al., 2010; Lungeanu and Contractor, 2015).

Our results contribute to the research on LDR in teams. This area of LDR has been seen as meriting more attention because of the potential it has for how teams function (Solansky, 2008; Zohar and Hofmann, 2012; Peng et al., 2015), as LDR is responsible for influencing people in order to orient, structure, and facilitate the activities and relationships of a group or organization (Solansky, 2008; Zohar and Hofmann, 2012; Peng et al., 2015). We also provide information linking LDR to cognitive variables such as TMS and networks. This study thus joins others that argue the positive effects of leaders on groups and organizations (Zaccaro, 2001; Sarros et al., 2008; Morgeson et al., 2010).

First, we find a direct and significant relationship between NT and TMSS in university R&D groups. Our results are interesting because they show that researchers who compose the work networks in university R&D groups recognize the advantage of depending on each other for specialized knowledge, a key to competitiveness (Grant, 1996). The results show that NT promotes specialization in these groups, since each person takes responsibility for the part in which he or she specializes and contributes it to the network to facilitate the work (Huang and Huang, 2007; Zhong et al., 2012). A strong, dense network encourages an attitude in the interested parties of searching for new opportunities and sharing experiences, particularly in dynamic and unpredictable environments (Baggio and Cooper, 2010). This characteristic of the network encourages TMSS, since TMSS benefits from having diverse members in the group who have specialized or very specific knowledge about something. Such knowledge makes the group dense and complex (Zhong et al., 2012), and diverse areas of knowledge within the R&D group (West, 2002) must be integrated to obtain valuable results.

The relationship between NT and TMSS in the presence of LDR was not significant. This result may be due to the level of autonomy of researchers in R&D groups. Although the members have specific, unique functions related to their specialization, each is responsible for his or her function in contributing to collective success (Zaccaro et al., 2001) and does not need support from LDR for this. Specifically, teams that are autonomous due to their high specialization have many advantages, which are applicable to university R&D groups, such as high creativity and knowledge exchange (Parker and Williams, 2001).

The significant relation between NT and TMSCR shows that working while tied into a network permits the members to increase their credibility, since they can communicate easily and more frequently (Gladwell, 2003). Further, the network enables better use of colleagues' knowledge, encouraging credibility (Burt, 2010; Wu, Lin, Aral, and Brynjolfsson, 2009). On the other hand, the relation between NT and TMSCO was also significant, demonstrating that work in a network is a way to organize work within and between organizations (Chen, Rainie, and Wellman, 2012). Riemer and Richter (2010) also indicate that networks support creation of conscience in the team and its coordination. This result is relevant for R&D groups, since high levels of coordination enable group members to work closely and fulfill their objectives better (Liu et al., 2014)

The positive and significant connection of NT with TMCR and TMCO in the presence of LDR is due to the fact that leadership facilitates integration and thus NT and, in turn, TMSCR and TMSCO. NT permit better communication and provide close connections between individuals, groups, departments, and organizations. In addition to helping to perceive the degree of competence available—and independently of the relationships that exist within the network (Tsai, 2002), which impact TMSCR and TMSCO—leadership improves relationships because it helps the team's members to work in a more coordinated way (Zaccaro et al., 2001). We know that most problems in a team come from its environment. Leaders must thus act in harmony with these changes (Ancona and Caldwell, 1988), enabling better NT and, in turn, better credibility and coordination in the TMS. The leader's function is to contribute to the team's effectiveness (Zaccaro et al., 2001).

To summarize, LDR improves the relation of NT to TMSCR and TMSCO, but this is not the case for TMSS. This result shows that working on R&D in a network is more complex and relevant for understanding research (Börner et al., 2010; Lungeanu and Contractor, 2015), since it permits obtaining results in groups that have not been undertaken by a single individual (Gupta et al., 2007). The foregoing highlights the current potential of analysis of networks for the science of groups (Wölfer et al., 2015), using LDR as the differentiating and integrating element (Balkundi et al., 2011). The current evolution of networks and the links created within them have significant implications for opportunity creation in groups. NT are fundamental to determining the group's strategy. By adopting network methods and concepts, groups can increase their development at group level, such as ties between individuals, their commitment to the group (Katz et al., 2004; Wölfer et al., 2015), and their credibility and coordination (Liu et al., 2014), all of which are encouraged by the role that leaders play in the different groups (Holten and Brenner, 2015).

Conclusions

The study's conclusions show that LDR is perfectly applicable to the university R&D environment because society today requires new leaders who can confront a knowledge-based reality (García et al., 2008). Further, its connection to cognitive variables such as NT and TMSCR and TMSCO is positive. The autonomy of the members of university R&D groups makes leaders' constant influence unnecessary. Thus, our result is innovative in contributing to a new management focus oriented to the researchers' autonomy, specifically in relation to TMSS. As the literature does not mention studies that have tested these effects empirically, our study contributes information to this theoretical gap.

This research has several limitations that suggest further possibilities for empirical research. For example, the research was cross-sectional in nature. In addition, the sample consists of several sectors of R&D that are not distributed equally, such that results may be influenced by the most significant groups, those with more representation. Further research would thus be useful to replicate the study findings using longitudinal analysis to extract further explanation and determine whether assumptions change over time. The future development of long-term analysis of groups and networks merits special attention (Katz et al., 2004; Lungeanu and Contractor, 2015). LDR is promising in strengthening this topic. Future studies could analyze the effect of shared LDR on R&D and on self-managed R&D teams, since the literature proposes that some teams are based on a single leader, while others are based on a collective feeling of shared leadership (Solansky, 2008). Finally, future research could use the network focus to examine a wider variety of groups, even groups classified by knowledge fields. As well study the effects of leadership intervention on specialised teams.

Implications for research, practice and/or society

The study provides significant contributions to practice. The results on moderation indicate that R&D groups should form internal research networks that allow TMS. It also shows that TMS will become stronger as long as group leadership within R&D enables them to develop. Therefore, the networks that have developed to become much stronger lead in TMS. Leaders should know how to motivate and teach, and how to involve others in a common project (Senge, 1990). Such skills are important for university R&D because of way in which TMS facilitates working in a group. The results described can guide group leaders of university R&D. Our study findings can be used to develop a specific program for individual leaders of a university R&D groups to obtain better results in their group. Further, a leader with knowledge of networks and TMS can lead his or her group more effectively. Thus, the groups provided better results to society.

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Table 1. Measurement scales

Leadership (adapted from Samson and Terziovski, 1999)
The people responsible for the group share similar beliefs about the future direction of the research group. The people responsible for the group actively foster change and the implementation of a culture of improvement, learning, and innovation toward “excellence.” Researchers have the opportunity to share and are encouraged to help the research group implement changes. There is a high degree of unity of purpose in our research group.
Transactive memory system (TMS) (adapted from Akgun et al., 2005)
Specialization Each member of the team has specialized in knowledge of some aspects of the research. I have knowledge about one aspect of the research that no other team member has. Different members of the team are responsible for different areas because of their experience. The specialized knowledge of various team members is needed to complete research and the final results.
Credibility I felt comfortable accepting procedural suggestions from other members of the team. I trust the knowledge other members have of the research. I really trust the information that team members bring for discussion.
Coordination My team worked together with good coordination. We manage to perform tasks efficiently and without problems. There is no confusion about how to carry out the tasks.
Network ties (adapted from Chiu et al., 2006)
I have a close social relationship with some members of my team. I spend a lot of time interacting with some members of the team. I know some members of my team on a personal level. I have frequent communication with some members of the team.

Table 2. Internal consistency of the measurement model employed

Variable	Alpha Cronbach (>0.7)	Initial no. of items	Final no. of items
LDR	0.872	4	4
TMSE	0.70	4	3
TMSCR	0.851	3	3
TMSCO	0.839	3	3
NT	0.883	4	4

Table 3. Confirmatory factor analysis of the measurement model used

Indicators	Factor Loadings	t-values	R^2	Measurement Error
LDR1	0.740	6.295	0.548	0.452
LDR2	0.862	7.240	0.743	0.257
LDR3	0.820	5.073	0.672	0.328
LDR4	0.758	6.847	0.575	0.425
TMSS1	0.697	7.368	0.486	0.514
TMSS2	Eliminated			
TMSS3	0.724	9.911	0.524	0.476
TMSS4	Eliminated			
TMSCR1	0.696	11.399	0.484	0.516
TMSCR2	0.898	16.703	0.806	0.194
TMSCR3	0.838	18.286	0.702	0.298
TMSCO1	0.716	8.092	0.512	0.488
TMSCO2	0.841	13.033	0.708	0.292
TMSCO3	0.851	10.204	0.724	0.276
NT1	0.952	6.106	0.907	0.093
NT2	0.731	6.249	0.534	0.466
NT3	0.797	4.958	0.635	0.365
NT4	0.865	5.603	0.749	0.251

Table 4. Descriptive statistics

	TMSS	TMSCR	TMSCO	NT	LDR
N (valid)	257	257	257	257	257
N (lost)	0	0	0	0	0
Mean	5.8983	6.3009	5.6550	5.7558	5.7704
Median	6.0000	6.3333	6.0000	6.0000	6.0000
SD	1.0181	0.8293	1.0397	1.2111	1.1585
Variance	1.03662	0.6877	1.0810	1.4668	1.3421

Table 5. Correlation matrix

	TMSS	TMSCR	TMSCO	NT	LDR
TMSS	1	0.528(**)	0.407(**)	0.218(**)	0.348(**)
TMSCR	0.528(**)	1	0.648(**)	0.274(**)	0.413(**)
TMSCO	0.407(**)	0.648(**)	1	0.263(**)	0.546(**)
NT	0.218(**)	0.274(**)	0.263(**)	1	0.245(**)
LDR	0.348(**)	0.413(**)	0.546(**)	0.245(**)	1

** The correlation is significant at 0.01 (two-tailed).

Table 6. Indicators of multicollinearity of the independent variables that compose the hypotheses analyzed

First Model - TMSS Second Model - TMSCR Third Model - TMSCO	Variable	Tolerance	VIF
1	Number of members	0.990	1.010
	Income	0.990	1.010
2	Number of members	0.981	1.020
	Income	0.985	1.016
	NT	0.986	1.014
3	Number of members	0.911	1.097
	Income	0.981	1.019
	NT	0.909	1.100
	LDR	0.873	1.146
4	Number of members	0.906	1.103
	Income	0.981	1.019
	NT	0.883	1.132
	LDR	0.863	1.159
	NT x LDR	0.943	1.060

Table 7. Regression analysis of LDR as variable moderating the relationship between NT and TMSS

Variables	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
	β	**Error**	**β**	**Error**	**β**	**Error**	**β**	**Error**
Constant	5.538***	(0.243)	4.414***	(0.378)	3.447***	(0.418)***	3.498***	(0.427)
Income	0.158	(0.071)	0.184	(0.070)	0.098	(0.069)	0.101	(0.070)
No. members	0.016	(0.092)	-0.010	(0.090)	0.014	(0.087)	0.014	(0.087)
Predictors								
NT			0.196***	(0.051)	0.130**	(0.051)	0.124**	(0.052)
Moderator								
LDR					0.255***	(0.055)	0.252***	(0.055)
Interactions								
NT x LDR							0. 021	(0.035)
F-value	2.549		6.684***		10.854***		8.732***	
R^2	0.020***		0.073***		0.147***		0.148	
Adjusted R^2	0.012***		0.062***		0.133***		0.131	
Change in R^2	0.020***		0.054***		0.074***		0.001	

Dependent variable: TMSS
Regression coefficients and standard deviations shown in parentheses
Significance level: *p<0.1, **p<0.05, ***p<0.01

Table 8. Regression analysis of LDR as variable moderating the relationship between NT and TMSCR

Variables	Model 1		Model 2		Model 3		Model 4	
	β	**Error**	**β**	**Error**	**β**	**Error**	**β**	**Error**
Constant	6.102***	(0.200)	4.599***	(0.310)	3.240***	(0.312)	4.420***	(0.314)
Income	0.072	(0.058)	0.098	(0.056)	0.010	(0.055)	0.022	(0.054)
No. members	0.023	(0.076)	-0.003	(0.073)	0.022	(0.068)	0.022	(0.067)
Predictors								
NT			0.194***	(0.041)	0.126**	(0.040)	0.106**	(0.040)
Moderator								
LDR					0.262***	(0.043)	0.249***	(0.043)
Interactions								
NT x LDR							0.378***	(0.027)
F-value	0.864		7.939***		16.041***		20.934***	
R^2	0.007		0.086***		0.203***		0.229***	
Adjusted R^2	0.001		0.075***		0.190***		0.214***	
Change in R^2	0.007		0.079***		0.117***		0.026***	

Dependent variable: TMSCR
Regression coefficients and standard deviations shown in parentheses
Significance level: *p<0.1, **p<0.05, ***p<0.01

Table 9. Regression analysis of LDR as variable moderating the relationship between NT and TMSCO

Variables	Model 1		Model 2		Model 3		Model 4	
	β	**Error**	**β**	**Error**	**β**	**Error**	**β**	**Error**
Constant	5.596***	(0.249)	4.599***	(0.310)	3.240***	(0.312)	4.420***	(0.314)
Income	0.125	(0.073)	0.157	(0.070)	0.003	(0.063)	0.013	(0.063)
No. members	-0.092	(0.095)	-0.124	(0.091)	-0.081	(0.079)	-0.081	(0.079)
Predictors								
NT			0.241***	(0.052)	0.122**	(0.047)	0.104**	(0.047)
Moderator								
LDR					0.458***	(0.050)	0.446***	(0.050)
Interactions								
NT x LDR							0.568***	(0.023)
F-value	1.802		8.514***		24.802***		29.439***	
R^2	0.014		0.092***		0.318***		0.331***	
Adjusted R^2	0.006		0.081***		0.308***		0.317***	
Change in R^2	0.014		0.078***		0.227***		0.012***	

Dependent variable: TMSCO
Regression coefficients and standard deviations shown in parentheses
Significance level: *p<0.1, **p<0.05, ***p<0.01

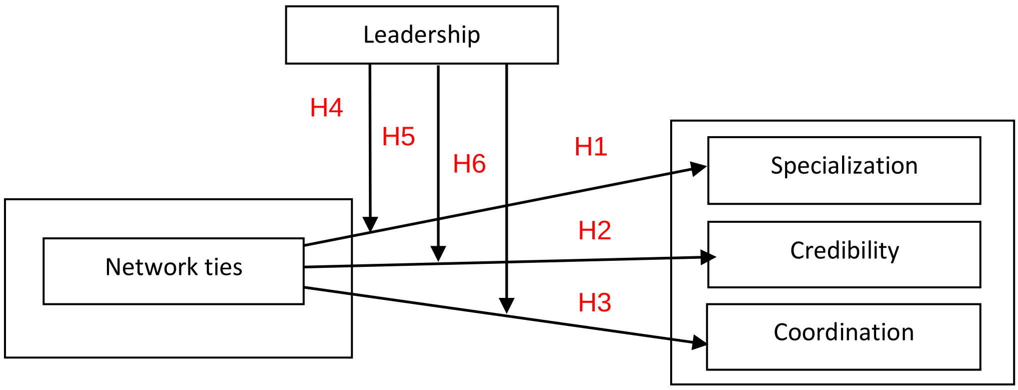

Figure 1 Conceptual research model