Transactional Memory Systems in virtual teams:
Communication antecedents and the impact of TMS components on creative processes and outcomes

Abstract

Acknowledging the increased importance of virtual teams in the context of Industry 4.0 and recently in COVID-19 pandemic, this study identifies and addresses several knowledge gaps regarding the development of an effective transaction memory system (TMS), and the influence of its components on team's knowledge sharing and creativity. To investigate these issues, we apply structural equation modelling using AMOS 21, on a sample of 477 managers, enrolled in a French Business School program. The results confirm - with one exception, the positive role of communication frequency and quality in the emergence of TMS components; only the relationship between communication frequency and specialization being non-significant. On the other hand, TMS components have a positive impact on knowledge sharing and team's creativity. Our study also unveils two counterintuitive findings, regarding the non-significant relationships between coordination and knowledge sharing, and respectively, credibility and creativity. These findings are interpreted and explained considering the specific context of virtual projects, leading to several theoretical and managerial implications regarding knowledge management and creativity in virtual teams.

1. Introduction

Creativity, defined as the production of novel and useful ideas about products, practices, processes or procedures (Amabile, 1996), represents an essential condition for business success. The rapid pace of change and new product/service introduction creates a highly competitive environment that requires a permanent effort to develop new ideas. In addition, globalisation has opened even local markets to foreign companies intensifying competition and reinforcing the need for creativity as a determining factor for firm competitiveness (Gino et al., 2009).

To address the challenge of being creative, many companies have developed project teams dedicated to new product and/or service ideas development (Barczak, Lassk and Mulki, 2010). These teams are often cross-functional (Zhang and Guo, 2019) and globally dispersed, to cover a more diverse range of knowledge, competencies and contexts, with interactions taking place virtually. This trend is accelerated by the emergence of Industry 4.0 systems (Kneisel, 2019) and by the impact on work of COVID-19 pandemic (Feitosa and Salas, 2020). For these reasons, virtual teams represent essential structures in modern organizations (Fang, Kwok and Schroeder, 2014; Siebdrat, Hoegl and Ernst, 2009), that can be defined as groups of people whose members are (1) geographically-distributed, (2) electronically-linked, (3) functionally and/or culturally diverse, and (4) laterally connected (DeSanctis and Monge, 1999). However, despite the increasing importance of virtual teams, few studies have studied the processes enhancing their creativity (Han et al., 2017).

The key to enhance virtual teams' creativity is to thoroughly understand the advantages and challenges raised by collective virtual interactions. For a long time, creativity was considered as the exclusive domain of individual experts (Chompunuch, Ribiere and Chanal, 2019), but the increasing complexity of global projects requires an ideation process that combines multiple areas of expertise at team level (Baruah and Paulus, 2009). For this reason, many organizations increasingly rely on the work of creative teams where each individual is an expert in a particular area (Paulus and Nijstad, 2003; Zhang and Guo, 2019), which ensures a high-quality pool of available knowledge. On the other hand, the lack of face-to-face interactions increases the difficulty of developing trust between members, which may negatively influence tacit knowledge sharing, task coordination, and team performance (Han et al., 2017; Zhang, Wang and Hao, 2020). In these conditions, the effective exploitation of diverse cognitive resources depends on the capacity of the virtual team to precisely map the available areas of expertise, develop trust among team members, and enhance intra-team coordination to ensure synergistic effects based on knowledge exchange (Curşeu, Schalk and Wessel, 2008). A team will achieve more creative breakthroughs, if its members learn from each other and gain a deeper understanding of a target/project by sharing distributed knowledge and experience (Baruah and Paulus, 2009).

Extant studies already outlined the importance of the Transactional Memory System (TMS) – defined as "the shared division of cognitive labour regarding the encoding, storage, retrieval, and communication of information from different domains that often develops in close relationships" (Hollingshead, 2001, p. 1080) when team members have high levels of individual expertise. However, the specific situation of virtual teams raises new and important challenges that require further research regarding both the antecedents leading to the formation of TMS components (i.e., specialization, credibility and coordination), as well as the effect of these components on intra-team knowledge exchange, and respectively, team creativity. Although TMS-related studies have flourished in the last 20 years, significant knowledge gaps remain in the managerial theory and practice regarding the determinants of TMS components and their impact on virtual team's creative processes and outputs (Cao and Ali, 2018).

To address these knowledge gaps, our study formulates and addresses the following research objectives: *(i) to identify and investigate the role of communication in the development of TMS components in virtual teams, and (ii) to assess how these components impact virtual team's knowledge sharing and creative performance.* These topics represent much more than simple gaps in academic knowledge, since many team and organization managers struggle to enhance virtual teams' creativity in a highly unpredictable work environment influenced by the COVID-19 pandemic. From this perspective, our study is essentially problem-driven, addressing real managerial challenges (Corley and Gioia, 2011).

This study makes a threefold contribution to the theory and practice of virtual team's creativity. First, it confirms the importance of communication frequency and quality to the development of TMS components. Second, it clarifies the role of TMS components in virtual teams' knowledge sharing and respectively, virtual teams' creativity. Finally, it validates a positive relationship between intra-team knowledge sharing and team's creativity. Our findings provide clear and important insights that aim to facilitate the understanding and work of academic researchers, virtual teams' leaders, and organizational managers who deploy and coordinate global projects.

2. Theoretical background

Although the extant literature differentiates between groups - defined as collections of individuals focused on an (individual) goal (Forsyth, 2006), and teams – described as groups that typically have a long-term relationship, are embedded in an organization, and work together on a common goal (Paulus, Dzindolet and Kohn, 2012), these concepts are often used as synonyms in creativity research (Chompunuch et al., 2019: Stollberger, West and Sacramento, 2017). In this study, we follow the latter logic found in creativity literature using the terms ‘groups’ and ‘teams’ interchangeably; referring in both cases to specific collective entities that perform within organisational boundaries trying to accomplish specific creative tasks.

Traditionally, most research on team creativity involved self-reports, with few studies analysing objective data regarding team performance (Antoni and Hertel, 2009; Hülsheger, Anderson and Salgado, 2009). On the other hand, group creativity research was mostly based on objective data, but often involving students in laboratory settings (Bolinger, Bonner and Okhuysen, 2009; Paulus et al., 2012). Newer studies have focused on the evolving situation of teams in organizations, the two research streams converging in terms of data collection, analysis, and findings (Buisine and Guegan, 2019; Chamakiotis, Dekoninck and Panteli, 2013; Han et al., 2017; Men et al., 2019).

2.1 Understanding creativity in virtual teams

While individual creativity is centred on the expertise, motivation and creative skills of an isolated person (Amabile, 1996), team creativity represents both a social process – involving interaction with other people, and a cognitive process – which requires the collective sharing of concepts, knowledge and experiences (Kneisel, 2019). These cognitive resources are retrieved from individuals’ memories, shared with other team members, and then further processed, combined and integrated to produce a broad range of creative ideas (Sternberg, 2006).

Diversity is an important factor in creative group performance (Paulus, 2000; Thompson, 2003; West, 2002). A team endowed with diverse areas of knowledge is much better equipped for creative tasks than a team composed of individuals with overlapping expertise (Paulus and Brown, 2007). The specialization and complementarity of team members can thus contribute to creativity and higher performance (Johnson and Johnson, 1989).

However, not all types of knowledge are easily transferable. Nonaka, Borucki and Konno (1994) distinguish between explicit and tacit knowledge. Explicit knowledge can be expressed and communicated in codified, systematic and formal ways (Nonaka et al., 1994; Smith, 2001), while tacit knowledge refers to the variety of action-oriented expertise based on practice and embedded in behaviours, way of thinking, and work style of people with different cultural and professional backgrounds (Smith, 2001; Wang and Ji, 2013). Whilst explicit knowledge is easily transferable, often in written or video format, tacit knowledge is difficult to formalize and communicate, especially in virtual teams (Cao et al., 2012).

In comparison with collocated teams, virtual teams present both specific advantages and challenges regarding group creativity (Martins, Gilson and Maynard, 2004). On the one hand, computer-mediated-communication (CMC) allows modern organizations to recruit and connect top experts regardless of their geographical location; on the other hand, the global dispersion of virtual team members determines a lack of face-to-face interactions, the exacerbation of socio-cultural differences, and dependence on communication technologies, complicating the management of intra-team knowledge processes (Aritz, Walker and Cardon, 2018; Fiol and O'Conner, 2005; Klitmøller and Lauring, 2013). The electronic connection of geographically-dispersed individuals does not necessarily lead to effective interpersonal communication, coordination and trust. As a result, intra-team interactions and new knowledge generation in virtual environments may be more prone to errors, delays, and misunderstandings (Hayward, 2002; Kauppila, Rajala and Jyrämä, 2011). As Kneisel (2019) points out: "virtual teams are thus in a field of tension between growing needs and technological opportunities for virtual knowledge integration on the one side and social challenges of managing knowledge processes over physical, social and cultural distances on the other side" (p. 186).

In these conditions, it is essential for virtual team members to interact and develop socio-cognitive mechanisms for engendering shared meaning and potentially enhancing virtual team processes and performance. Promoting relational confidence and coordination enable team members to co-create and absorb mutual knowledge (Leal-Millán et al., 2016) defined as knowledge that communicating parties share and that each party knows that they both possess (Davis and Khazanchi, 2006; Krauss and Fussell, 1991). In this respect, TMS seems to play a significant role, facilitating knowledge mapping, retrieval, and sharing at team level (Choi, Lee and Yoo, 2010).

2.2 TMS and virtual teams

Extant literature suggests that the development and use of TMS represent central team processes required for group creativity, enabling team members to map individual expertise (specialization), increase trust in other members' knowledge (credibility), and promote effective knowledge processing (coordination) (Zhong et al., 2012).

Surprisingly, the extant literature does not offer, a clear, formal definition of these three TMS components. Their existence was first demonstrated by Liang, Moreland and Argote (1995) who studied the interaction of team members in assembling a radio: "Three cognitive factors, all of which were assumed to reflect the operation of a transactive memory system among team members, were coded from the video-tapes. The first factor was memory differentiation, or the tendency for group members to specialize in remembering distinct aspects of assembling the radio. […] The second factor was task coordination, or the ability of group members to work together smoothly while assembling the radio. […] Finally, the third factor was task credibility, or how much group members trusted one anothers' knowledge about assembling the radio." (pp. 388-389). Lewis (2003) who developed and validated a TMS measurement scale, provides the following description of the three components: "TMSs could be discerned from the differentiated structure of members' knowledge (specialization), members' beliefs about the reliability of other members' knowledge (credibility), and effective, orchestrated knowledge processing (coordination)" (p. 589). Based on the extant literature (Lewis, 2003; Liang et al., 1995; Moreland and Myaskovsky, 2000; Zhang et al., 2020), we propose the following definitions of these three TMS components:

- specialization refers to the ability of a group to recognising who knows what and how this knowledge can be used in favour of the group to act in a more effective manner;
- coordination is associated with the necessity of thorough planning during the completion of the group task or project;
- credibility refers to the extent team members consider as proper and accurate any information and/or task knowledge shared by other members; when a team has developed a TMS, members of the team tend to see other members as credible, sharing correct knowledge.

Some researchers define TMS as a latent second-order variable composed of three first-order components (Ashleigh and Prichard, 2012; Choi et al., 2010; Lewis, 2003; Maynard et al., 2012). Although these components covary due to a common cause (i.e., the existence of

TMS) (Lewis and Herndon, 2011), they are considered theoretically distinct, as specialization and credibility are cognitive elements, while coordination represents a behaviour (Lin et al., 2012; Wang et al., 2018; Zhong et al., 2012). Alternatively, TMS can be described as a collection of socio-cognitive emergent states (Kanawattanachai and Yoo, 2007) these three components representing "abilities that are often found in teams with highly developed TMS" (p. 786). Lewis and Herndon (2011) advocate research flexibility and discrimination stating that the "choice of an appropriate TMS measure should be made based on considerations about study design (e.g., laboratory or field) and on the research questions of interest" (p. 1257). Following this suggestion, we address the development and functioning of TMS' structure, transactive processes, and their interplay, by considering the three TMS components as research variables. From this perspective, TMS represents a socio-cognitive mechanism shared by team members that is characterized by the simultaneous existence of three team-level emergent states – specialization, credibility, and coordination, that are engendered and maintained through repeated interpersonal interactions.

However, TMS development can be challenging in virtual teams due to the high tacit knowledge heterogeneity of various members (Zhang et al., 2020). Cultural distance and CMC may have a negative impact on interpersonal interactions (Alawi and Tiwana, 2002; Cordery and Soo, 2008) reducing the effectiveness of knowledge mapping, sharing, and coordination at team level (Kanawattanachai and Yoo, 2007). These recognized challenges require further investigation regarding both the antecedents of TMS components, as well as their effect on subsequent team processes and outputs. The study of Kanawattanachai and Yoo (2007), addresses some of these issues, but lacks to offer a more specific view of team creativity in a virtual environment. First, although they consider communication as an antecedent of TMS components' development, Kanawattanachai and Yoo (2007) use the concept of task-oriented communication, which does not permit to clearly assess the impact of various communication dimensions - such as frequency or quality - on TMS components. Second, they imply an effect of task-oriented communication only on two TMS components - specialization and credibility, neglecting the relationship between task-related communication and coordination. Third, although they develop a model regarding the functioning of the three TMS components in virtual teams, they provide no evidence of how specialization and credibility are linked to virtual team performance. Fourth, they focused on the generic aspects of team performance, neglecting the importance and specificity of creativity as a particular aspect of virtual team performance. Addressing these knowledge gaps, our study attempts to understand the mechanism of achieving team performance in a virtual setting focusing on creativity, but also incorporating in the empirical model critical variables for virtual team's development and functioning: communication and knowledge sharing.

3. Hypotheses development

3.1 Communication and TMS components

Extant literature has repeatedly outlined the role of communication in the emergence and maintenance of TMS (Liao et al., 2012; Peltokorpi and Hood, 2019; Yan et al., 2021), both in terms of communication quantity and quality. Communication quantity is defined as "a combination of volume and frequency to reflect the notion that teams can frequently or infrequently have large or small amounts of interactions with each other" (Liao et al., 2012, p. 215), whereas communication quality refers to the extent to which communication among team members is perceived as timely, correct, relevant and useful to perform the common task (Chen et al., 2013; Liao et al., 2012).

During the early phases of group development, frequent communication enables members to develop accurate, shared perceptions of member-expertise associations by providing them with opportunities to establish who knows what (Peltokorpi and Hood, 2019). Group members can describe their qualifications, state their lack of expertise in certain domains, respond to questions, and solicit information from other members (Hollingshead, 1998; Lewis, 2004), contributing to TMS formation. Through communication, team members gradually build trust in one another's expertise knowledge (credibility), develop a differentiated memory structure (specialization), and engage in orchestrated knowledge processing and exchange (coordination) (Lewis, 2003; Moreland and Myaskovsky, 2000; Yan et al., 2021).

Communication plays a central role in virtual teams, since "in virtual environments, where team members have no prior experience in working together, nor they have any joint training or team building exercise, interactions via communication media will be the primary means of developing transactive memory systems" (Yoo and Kanawattanachai, 2001, p. 190). In virtual projects, the quality of communication is often valued more than its sheer volume (Chen et al., 2013). Given the differences in time zone, geographical location and socio-cultural background between various team members, a timely and relevant communication can foster a sense of cohesion, interpersonal trust and social identity. Virtual teams with high levels of trust tend to engage in frequent communication, focus on work topics, and adequately socialize during the early stage of the project (Iacono and Weisband, 1997).

Despite the rich literature developed regarding the role of communication in TMS development, there are surprisingly few studies that explicitly investigate the impact of communication frequency, volume and quality on TMS formation. Yoo and Kanawattanachai (2001) analyse and demonstrate the role of communication volume for TMS development in virtual teams, but communication frequency and quality – although discussed in some studies (Chen et al., 2013; Kanawattanachai and Yoo, 2001), are not explicitly tested as TMS antecedent variables.

The extant literature provides, however, some indirect arguments for a positive association between these communication dimensions and the TMS components (Liao et al., 2012). Frequent and high-quality communication facilitates the development of shared and accurate perceptions regarding various member-expertise associations (Lewis, 2004; Tang, 2015), enhances intra-team coordination (Liao et al., 2012), and builds a valuable social capital expressed through trust and credibility (Joshi, Sarker and Sarker, 2007; Liao et al., 2015; Tang, 2015). Considering these arguments, we formulate the following hypotheses:

H1a: Communication frequency is positively associated with specialization.

H1b: Communication frequency is positively associated with coordination.

H1c: Communication frequency is positively associated with credibility.

H2a: Communication quality is positively associated with specialization.

H2b: Communication quality is positively associated with coordination.

H2c: Communication quality is positively associated with credibility.

3.2 TMS components and knowledge sharing

Knowledge sharing refers to the process of locating distributed knowledge in an organization and transferring/using it to/in other context(s) (Alavi and Leidner, 2001). In our study, knowledge sharing is characterized by the extent to which team members exchange, elaborate and integrate various knowledge sources to facilitate and enact the development of creative ideas. Through participation and interaction, the knowledge provided by one team member becomes the cue for other members to retrieve relevant but different knowledge stored in their own memory (Wegner, Giuliano and Hertel, 1985). Similarly, a virtual team context creates specific issues regarding knowledge sharing. A study by Rosen, Furst and Blackburn (2007) identified six barriers of knowledge sharing in virtual teams, namely, building trust relationships, time, technology, team leader behaviour, failure in developing an effective TMS and finally, cultural constraints.

In other words, virtual teams experience critical challenges in knowledge sharing that complexity their functioning. Knowledge exchange is not just a simple, linear knowledge transfer between virtual team members, representing an iterative process of expressing and integrating different perspectives, insights and interpretations, which eventually results in a range of creative ideas that are qualitatively different from extant knowledge (Chen et al., 2013). Zhang, Hong and Ling (2012) indicate that functional TMS can enhance the quality and relevance of tacit knowledge and concurrently improve its effectiveness, sharing and integration.

Knowledge specialization of various virtual team members not only enriches the pool of available cognitive resources, but also determines a knowledge-relevant interdependence among individuals, which reinforces the need for interpersonal knowledge sharing to pursue the common team goal(s) (Argote and Miron-Spektor, 2011; Heavey and Simsek, 2017). In addition, the shared awareness regarding the specialized knowledge of each team member (Gutwin, Penner and Schneider, 2004; Wegner, 1987; Zahedi, Shahin and Babar, 2016) acts as a clue for accurately locating experts (Argote and Ren, 2012; Faraj and Sproull, 2000) and involving them, when necessary, in the knowledge sharing process. Often, the experts themselves can identify a need for their knowledge, voluntarily interacting in a timely manner with other virtual team members (Rico et al., 2008). In a virtual context, specialised knowledge of team members supports virtual teams' function as "knowledge activists" that in turn enhance information and knowledge sharing in geographically-dispersed organisations (Kauppila et al, 2011). Based on the above theoretical arguments we formulate the following hypothesis:

H3a: Specialization is positively associated with knowledge sharing.

Coordination refers to orchestrated virtual team-level knowledge processing (Lewis, 2003) by appropriately dividing and assigning tasks among members based on individual expertise, shared work procedures, and schedules (Brandon and Hollingshead, 2004; Kanawattanachai and Yoo, 2007; Zhu, 2009) to integrate the expertise, actions, and objectives of individuals with a common goal (Rico et al., 2008). Coordination implies the existence of a shared objective and understanding that motivates virtual team members to overcome cognition biases and actively engage in collective processes (Li and Huang, 2013; Lin et al., 2012; Eisenberg & Mattarelli, 2017). Through coordination, knowledge exchange can be implemented more effectively, leading to better interpersonal interaction and sharing (Hinds and Weisband, 2003; Chen et al., 2013). Following this rationale, we hypothesize that:

H3b: Coordination is positively associated with knowledge sharing.

Credibility reflects team members' beliefs about the reliability of others' expertise and their willingness to act based on such perceptions (Lewis, 2003), representing cognition-based trust in a virtual environment (Kanawattanachai and Yoo, 2007). Trustworthiness and reputation of a knowledge source powerfully signal its value, usefulness, quality, and validity, facilitating the acceptance and integration of each team member into the knowledge sharing process as a reliable participant (Chen et al., 2013; Joshi et al., 2007; Topchyan, 2015; Wang et al., 2018). Moreover, virtual team members motivated by cognitive-based trust are more willing to interrelate their actions with others and actively contribute knowledge (Lin et al., 2012; Zhong et al., 2012); otherwise, some members may be reluctant to share information for fear that some of their colleagues are not competent to create a knowledge backflow (Zahedi et al., 2016; Usoro et al., 2007). On this theoretical basis, we formulate the following hypothesis:

H3c: Credibility is positively associated with knowledge sharing.

3.3 Knowledge sharing and team creativity

Collective creativity emerges in social interactions, producing solutions that are often replications, adaptations or combinations of existing knowledge (Sternberg, 2006) dispersed amongst team members (Hargadon, 1998, 2002; Hargadon and Sutton, 1997): "rather than viewing this eureka moment as the sole province of individual cognition, this perspective focuses on those insights that emerge in the interactions between individuals" (Hargandon and Bechky, 2006, p. 484). Knowledge sharing seems to be equally important for virtual teams (Pangil and Chan, 2014)

Research supports the idea that cognitive resources available within a virtual team will be underutilized if knowledge is not shared (Argote, 1999; Belbaly and Somsing, 2016). Knowledge sharing is thus a critical virtual team process that require team members to interact in order to share ideas, information, and suggestions relevant to the team's task (Srivastava, Bartol and Locke, 2006; Leung and Wang, 2015).

The expertise, specialization and leadership skills of virtual team members provides cognitive resources for creativity (Gong, Huang and Farh, 2009; Hahm, 2017). However, the potential to create novel ideas as a virtual team is dependent on members' ability to efficiently exchange knowledge and build on each other's ideas (Han et al, 2017; Carmeli, Gelbard and Reiter-Palmon, 2013; Gong et al., 2009; Hargadon and Bechky, 2006). Current research on knowledge sharing and transfer in virtual teams suggests that sharing extant knowledge leads to new knowledge creation (Cao and Ali, 2018; Kneisel, 2019). Considering these theoretical arguments, we formulate the following hypothesis:

H4: Knowledge sharing is positively associated with team creativity.

3.4 TMS components and team creativity

Current literature indicates that both collocated and virtual teams can improve their performance by developing and using TMS, especially for complex tasks that require knowledge contributions from all virtual team members (Yoo and Kanawattanachai, 2001; Choi et al., 2010). The use of TMS as a knowledge management tool (Sung and Choi, 2012) is likely to improve team creativity (Gino et al., 2010) by offering team members a greater supply of task-related information and knowledge, which are the raw materials for creativity (Paulus, 2000; Taggar, 2002; Taylor and Greve, 2006), and by promoting knowledge application (Gino et al., 2009): "the shared and accurate awareness of team members' specialization and the trust in the specialization […] provide an appropriate environment and conditions for generation of creative ideas" (Zhu, 2009, p. 26).

Knowledge specialization reduces the cognitive load of each individual while providing the virtual team with access to a larger pool of task-related information across various domains (Brandon and Hollingshead, 2004; Farr, Sin and Tesluk, 2003; Hollingshead, 1998). The greater the diversity of relevant knowledge available at team level, the greater the probability of team creativity through combining, elaborating and integrating different professional or technical perspectives into novel ideas (Baer, 2010; Huang and Hsieh, 2017). Knowledge of who knows and does what may also lead to creative solutions by enabling team members to combine members' expertise in new ways (Gino et al., 2009). Based on the above arguments, we hypothesize that:

H5a: Specialization is positively associated with team creativity.

Knowledge complementarity amongst virtual team members requires good intra-team coordination to facilitate interactions and mutual understanding, reducing possible conflicts that hinder creativity (Gino et al., 2009; Lovelace, Shapiro and Weingart, 2001). The willingness to integrate and coordinate the diverse contributions and perspectives of other members enhances team's ideational synergy that results from interpersonal interactions (Bolinger et al., 2009; Paulus and Brown, 2007; Tiwana and McLean, 2005). Through cognitive and behavioural coordination, team members integrate task-relevant knowledge more smoothly and effectively in the general flow of ideas, therefore increasing the efficiency of the creative process (Huang and Hsieh, 2017). Based on these arguments, we proposed that:

H5b: Coordination is positively associated with team creativity.

Previous studies indicate that creativity is improved when team members mutually trust their teammates' expertise (Barczak et al., 2010; Huang and Hsieh, 2017; Ren and Argote, 2011). Credibility enhances openness and interaction between participants in collective work sessions, facilitating the expression of daring, new and creative ideas and their integration in a shared ideation flow (Mostert, 2007). Building on each other's input thus leads to collective insights that represent more than the sum of individual contributions (Hargadon and Bechky, 2006; Paulus and Brown, 2007). In this respect, we formulate the following hypothesis:

H5c: Credibility is positively associated with team creativity.

3.5 Proposed empirical model

The proposed relationships between variables expressed in the formulated hypotheses are integrated into the model presented in Figure 1.

Take in Figure 1

4. Methodology

4.1 Data Collection

To empirically validate the proposed model, we collected primary data from a sample of 650 young middle-level managers, considered as those working above first-line supervision level and below executive level. The middle managers (Psychogios, Alexandris and Onofrei, 2008) included in our sample were enrolled in an executive education program in a French Business

School. The participants were randomly allocated to teams of five, and engaged in the competitive process of developing and proposing creative ideas for introducing new features in a specific product category (home appliances for a multinational company) through an open innovation project that lasted four months. The setting of the exercise was realistic, reproducing the working conditions experienced by geographically dispersed virtual teams: lack of face-to-face interactions, no joint collaboration experience, little initial knowledge about each other's expertise and professional background, interpersonal CMC, and horizontal peer-to-peer relationships.

Primary data was collected through an online survey sent to all participants at the end of the exercise, as well as from a team of experts that evaluated teamwork outcomes. The questionnaire was developed using secondary data collected in the literature review stage, and it was pilot tested on three teams comprising of 5 participants each (15 in total).

From the initial sample of 650 participants, 477 returned complete and therefore usable responses, representing a 73% response rate.

Regarding the demographic profile of the respondents, 44% of responses were provided by female participants, and the rest by male participants. The age of participants ranged between 25 and 39 years old, most of them (62%) being employed by middle sized organizations - firms with 50 to 250 employees, and 29% in large companies with more than 250 employees. The participants worked in various French regions, with a small predominance of the Occitanie region where the school was situated: Auvergne - Rhône-Alpes (8.1%); Bretagne (7%); Bourgogne - Franche-Comté (7.2%); Corse (7.3%); Centre - Val de Loire (7.1%); Grand Est (7.1%); Hauts de France (7%); Ile de France (Paris) (7.2%); Nouvelle Aquitaine (7.1%); Normandie (7%); Occitanie (12.4%); Pays de la Loire (7.1%); Provence - Cote d'Azur (8.4%).

4.2 Measurement

All variables were measured using multi-item scales previously validated in the extant literature (see the Appendix). As a result of the pilot test, some items have been eliminated or slightly reworded to reflect the research context. All items were measured on a seven-point Likert-type scale, 1 meaning "strongly disagree" and 7 "strongly agree".

Communication quality was measured applying the three first items of the scale developed by Stewart and Gosain (2006), including the most relevant criteria (i.e., timeliness, correctness, usefulness, thoughtfulness) for measuring communication quality in a virtual environment. For this scale, we obtained an internal reliability (based on Cronbach's alpha score) of 0.841. All three items loaded to one general dimension of communication quality.

To evaluate the perception of online communication frequency of the virtual team members, we measured a three items scale that we have adapted from Penley and Hawkins (1985). Considering that every virtual team is different in terms of communication needs, we used the criteria related to frequency and types of communication. The analysis provided an internal reliability of 0.769. All three items loaded to one general dimension of communication frequency.

The three TMS components – specialization, coordination, and credibility - were evaluated using the initial scales developed by Lewis (2003). After pilot testing the measurement scales, we eliminated one item from the Specialization scale, and two items from the Credibility scale, to solve issues related to misunderstanding or irrelevance. After modification, the internal reliability of the three scales (based on Cronbach's alpha score) is, respectively, 0.832 for Specialization, 0.889 for Coordination, and 0.904 for Credibility.

Knowledge sharing was measured combining the scales used by Choi et al. (2010): two items, and Suh and Shin (2010): two items. This hybrid scale allowed us to measure team members' perceptions regarding various forms of shared knowledge (Choi et al., 2010), as well as the quality of the shared knowledge (Suh and Shin, 2010). The internal scale reliability analysis provided a score of 0.863.

Finally, we applied the five items measurement scale developed by Rego et al. (2007) to evaluate the perceptions of team members regarding the level of team creativity. The analysis of the initial sample led to an internal reliability score of 0.904 for this measurement scale. The items, and their factor loadings after exploratory factor analysis, eigenvalue, and percentage of variance explained, are presented in Table 1.

Take in Table 1

4.3 Validity

Several tests were applied to assert the validity of measures at individual respondent level. We began by testing the validity of the applied scales. To realize the confirmatory factor analyses (CFA), we used the maximum likelihood estimation, running the tests on AMOS 21. The results indicated a good fit for the proposed model: $\chi2$ = 724.798 (313), $\chi2$/d.f. = 2.392, IFI = 0.952, CFI = 0.951 and RMSEA = 0.051. All factors loadings were above a 0.50 threshold and significant. We obtained the following AVE scores: Communication frequency (0.51), Communication quality (0.65), Specialization (0.59), Coordination (0.61), Credibility (0.69), Knowledge sharing (0.64), and Team creativity (0.65), all of them adequate. The square roots of all AVE scores were larger than the corresponding correlations scores of all the possible pairs of variables; discriminant validities were thus sustained.

To further test the common method bias, we followed the approach of Ruey-Jer, Sinkovics and Kim (2014), applying five (items composition, need to separate the measurement, respondent anonymity, question order, Harman's one factor) of the six steps' procedure (partial correlation) recommended by Podsakoff et al. (2003). The results confirmed that common method bias was not a serious concern, allowing us to test the research hypotheses (Podsakoff et al., 2003).

We then examined the inter-rater coefficients (rwg: James, Demaree and Wolf, 1984) to confirm a strong inter-rater agreement before aggregating individual measures into team-level measures. The rwg (mean) coefficients of each construct were 0.75 or higher (see Table 2) than the cutoff value of 0.70, asserting a strong inter-rater agreement (James et al., 1984).

We also measured the inter-rater reliability. To achieve this, we computed ICC (1) and ICC (2) to decide on the appropriateness of aggregating perceptual variables into group-level data (James, 1982). All ICC (1) values exceeded the accepted cutoff value of 0.12 (De Jong and Elfring, 2010; Glick, 1985), ranging from 0.52 to 0.75, whereas the ICC (2) values were ranging from 0.77 to 0.90. Table 2 presents the descriptive statistics at team level, including rwg, ICC(1) and ICC (2).

Take in Table 2

At team level, the sample size was n = 107, with 27 original observed items. As we have a small sample, we applied the partial aggregation approach of structural equation modelling to test the proposed model at team level (Bentler and Chou, 1987). The partial aggregation approach retains each separate underlying factor while aggregating the indicators for each dimension of the overall construct (Bagozzi and Heatherington, 1994).

We ran a CFA to test the overall model (Von der Heidt and Scott, 2007), obtaining an acceptable fit: $\chi2$ = 406.99 (303), $\chi2$/d.f. = 1.343, IFI = 0.944, CFI = 0.942 and RMSEA =

0.057. All latent variables AVE scores are above the 0.50 threshold and their AVE square roots are larger than their corresponding correlations, which validates the discriminant validity test (Fornell and Larcker, 1981). We also tested the common method bias at team level with the one factor CFA model. The results showed a very poor fit: $\chi 2$ = 947.07 (325), $\chi 2$/d.f. = 2.923, IFI = 0.658, CFI = 0.653 and RMSEA = 0.135. Appendix A presents the models comparison at team level, the proposed seven-factor structure being clearly superior to all the other models.

We employed structural equation modelling to test our model (see Figure 1). The model achieved an adequate fit: $\chi 2$ = 434.805(310), $\chi 2$/d.f. = 1.403, IFI = 0.932, CFI = 0.930 and RMSEA = 0.062. Table 3 also presents the model fit comparison between the proposed model and two other competing models (see the Notes of Table 3).

Take in Table 3

4.4 Hypotheses testing

The estimation results for the proposed model are presented in Table 4 and in Figure 2.

Hypotheses 1a, 1b, and 1c posit a positive association between Communication frequency and, respectively, Specialization, Coordination and Credibility. The SEM results validate H1b ($\beta = 0.38$, $p < 0.01$) and H1c ($\beta = 0.39$, $p < 0.01$), but contradict H1a, as the relationship between Communication frequency and Specialization is not statistically significant ($p > 0.1$).

The results displayed in Table 4 validate the hypotheses regarding the relationship between Communication quality and the three TMS components: (H2a) Specialization ($\beta = 0.49$, $p < 0.01$), (H2b) Coordination ($\beta = 0.43$, $p < 0.001$), and (H2c) Credibility ($\beta = 0.51$, $p < 0.01$).

Take in Table 4

Among the three hypotheses that predict a positive relationship between the TMS components and Knowledge sharing, H3a and H3c are validated, indicating that Specialization ($\beta = 0.33$, $p < 0.05$), and respectively, Credibility ($\beta = 0.54$, $p < 0.01$) are positively associated with intra-team Knowledge sharing. On the other hand, H2b is not validated, the results indicating a non-significant relationship between Coordination and Knowledge sharing.

Take in Figure 2

Hypothesis H4 regarding the positive relationship between Knowledge sharing and Team creativity ($\beta = 0.26$, $p < 0.1$) is validated.

Hypotheses H5a and H5b are validated, confirming the existence of a statistically significant positive association between Specialization and Team creativity ($\beta = 0.36$, $p < 0.01$), and, respectively, Coordination and Team creativity ($\beta = 0.39$, $p < 0.01$). On the other hand, the relationship between Credibility and Team creativity is not statistically significant, and thus, H5c is not validated ($p < 0.1$).

Considering the explained variance of the main variables, the proposed model explains 34% of the variance in Specialization, 53% of the variance in Coordination, and 63% of the variance in Credibility. In what concerns Knowledge sharing, the proportion of explained variance is 66%, and finally, for Team creativity, is 53% (see Table 4).

5. Discussion

Our empirical results provide interesting insights regarding (i) the role of communication dimensions involved in developing the socio-cognitive structure and processes expressed by the three TMS components, (ii) the relationships between TMS components and knowledge sharing, and (iii) the influence of TMS components and knowledge sharing on virtual team's creativity.

5.1 Communication dimensions and TMS components

With one exception, both frequency and quality of intra-team communication are positively associated with the development TMS components. Communication quality – evaluated in terms of timeliness, correctness and usefulness – plays a substantial role in developing virtual team's knowledge specialization, coordination, and credibility. In addition, communication frequency is essential for achieving knowledge coordination and credibility, but has no influence on knowledge specialization. This situation can be explained considering the dynamics of knowledge specialization within virtual teams. Usually, the decision to allocate a specific knowledge area to a particular team member is based on the extant expertise and experience of that person (McComb, 2007). For this reason, the intra-team division of knowledge is often part of the initial team profile, requiring only few messages to cognitively map the intra-team knowledge specialization.

The central role of communication quality and frequency supports the findings of Maynard et al. (2012) regarding the importance of intra-team interaction for TMS development, as well as the results of Kanawattanachai and Yoo (2007) regarding the influence of task-oriented communication on various TMS components. However, the approach adopted in our study requires some further clarifications in relation to these extant studies. First, contrary to Maynard et al.'s (2012) study, we consider that the influence of communication on TMS' manifestations is not limited to the preparatory phase, shaping the evolution of Specialization, Coordination and Credibility during the entire project duration.

Second, although the specific effects of the communication dimensions considered in our study cannot be directly compared with the results obtained by Kanawattanachai and Yoo (2007), as in their paper communication frequency and volume are integrated into a second-order variable named "task-oriented communication", their findings related to the temporal effect of intra-team communication clarify some of our results. In time, the influence of task-oriented communication on specialization is reversed (Kanawattanachai and Yoo, 2007), which may explain the non-significant relationship between communication frequency and specialization obtained in our study. It is thus possible that the importance of communication on the cognitive mapping of team members' knowledge specialization is limited to a few initial messages, disappearing or being reversed in the later phases of team interaction.

5.2 TMS components and knowledge sharing

Testing the relationship between TMS components and knowledge sharing, we obtained some interesting results, unveiling the specificities of intra-team knowledge management in virtual groups. Specialization and credibility have a significant positive relationship with knowledge sharing. These results were expected, since both TMS components enhance team members' need and capacity to share their expert knowledge. Through specialization, virtual team members are forced to participate in the knowledge sharing process in order to create a knowledge pool that is large and diversified enough to lead to creative ideas (Curşeu, Schruijer and Boros, 2007; Mitchell and Nicholas, 2006). On the other hand, the cognitive credibility of team members induces acceptance, openness and respect for their expert contribution during the knowledge sharing process (Zhu, 2009). The positive links between these TMS components and knowledge sharing confirm the importance of team-level socio-cognitive structures and processes in facilitating an open and effective sharing of information, opinions, and ideas between virtual team members.

Somehow surprisingly, intra-team knowledge coordination has no significant relation with knowledge sharing. This counterintuitive result was clarified after interviewing a few team participants. The explanation is related to the theoretical conceptualization of teams' knowledge coordination (Gabelica et al., 2016), and the specific challenges experienced by virtual teams to engage in interpersonal knowledge sharing.

Regarding the theoretical definitions of coordination, the literature provides two perspectives: coordination as "output" (i.e., state of coordination or coordination success), considered as a result or component of emergent knowledge structures (e.g., TMS), and coordination as team "process" (i.e., coordinating) (Espinosa, Lerch and Kraut, 2004). The counterintuitive result of our analysis may be determined by a contradiction between the operational use of knowledge coordination for TMS formation – as a result, and for achieving knowledge sharing – as a process. Although in the first case the knowledge coordination still represents a valid TMS component indicating the existence of an effective TMS system in the investigated virtual teams, the process of knowledge coordination during knowledge exchange processes can be defined as "orchestrating the sequence and timing of interdependent actions" in the team (Marks et al., 2001), which include information exchange and behavioral adjustments. For example, to achieve knowledge sharing, participants will attempt to coordinate their contributions and behaviours in relation to other team members (Brannick, Roach and Salas, 1993), and in the context of knowledge sharing mechanisms deployed to facilitate and structure intra-team interaction (Espinosa et al., 2007).

The literature indicates the existence of several knowledge sharing mechanisms that are used depending on the specific characteristics of various teams and tasks (Wickramasinghe and Widyaratne, 2012): brainstorming and collaborative problem solving (Berends et al., 2006; Huang and Newell, 2003), team work processes (Al-Alawi, Al-Marzooqi and Mohammed, 2007; Garrett and Caldwell, 2002), storytelling (Fong and Chu, 2006), training (Al-Alawi et al., 2007), informal chatting (Al-Alawi et al., 2007; Fong and Chu, 2006; Newell et al., 2006), face-to-face meetings, project briefing and reviewing sessions (Fong and Chu, 2006), and information technology-based mechanisms such as teleconferencing, newsgroups, e-mail, Wikis, web-based discussions, and knowledge sharing boards (Fong and Chu, 2006; Hall, 2001; Jones and Borgman, 2007).

To solve the problems related to technical, temporal and process coordination that are specific for virtual teams, knowledge sharing mechanisms are mostly promoting asynchronous interactions, while in face-to-face teams, the knowledge sharing sessions are often organized in a synchronous interaction mode. In face-to-face teams engaged in synchronous communication "only one person can talk at one time" (Baruah and Paulus, 2009, p. 33), which require interpersonal timing and content coordination to effectively enact a knowledge sharing session. However, virtual teams usually prefer asynchronous modes of communication, using computer-based interactive platforms or applications that transmit and archive their members' contribution to the team project (Malhotra and Majchrzac, 2004), which eliminates the need of strict timing and content coordination, as participants can simultaneously contribute to several different knowledge flows (Zhuge, 2002). A sign that knowledge coordination may not represent a relevant condition for knowledge sharing in virtual teams is the decision of Chen et al. (2013) to eliminate knowledge coordination from their list of TMS components – and as a determinant of knowledge sharing, outlining instead the central role of mailing lists and other project artefacts, such as repository logs, issue and bug trackers for globally-distributed teamwork. In light of this evidence, we explain the counter-intuitive result regarding the relationship between coordination and knowledge sharing using two arguments. First, the coordination defined as a TMS component does not represent the type of coordination required to facilitate knowledge sharing processes. Second, the asynchronous mechanisms primarily used to achieve knowledge sharing in geographically distant virtual teams reduce or even eliminate the relevance of timing and content coordination among team members.

5.3 TMS components and creativity

Our study also clarifies the relationship between the TMS components and virtual team creativity. Two TMS components (i.e., specialization and coordination) have a statistically significant, positive association with team creativity. These findings reinforce the logic of virtual work based on a deep specialization of team members, complemented by clear rules of intra-team interaction. We thus confirm the findings obtained by Kanawattanachai and Yoo (2007) regarding the positive effect of knowledge coordination on team performance, and further we demonstrate the existence of a direct relationship between specialization and team creativity.

However, credibility does not have a statistically significant relationship with team creativity, which represent a counterintuitive result. The literature defines knowledge credibility as cognitive trust, which is based on team members' belief in their colleagues' expertise and reliability (McAllister, 1995). Extant studies do not provide consistent findings (Bidault and Castello, 2009). In some cases, credibility or cognitive trust has a positive relationship with team creativity (Barczac, Lassk and Mulki, 2010; Wei, Thurasami and Popa, 2018), in other papers its influence is not direct, but mediated by other team processes such as knowledge sharing (Wu, Zhao and Pan, 2016), team creative efficacy (Ali, Wang and Khan, 2019) or knowledge creation capability (Cao and Ali, 2018), while in yet other studies, the effect on creativity varies depending on the level of trust (Bidault and Castello, 2009 and 2010).

Several interesting studies (Porac et al., 2004; Skilton and Dooley, 2010) indicated that repeat collaboration, and consequently the existence of TMS, can suppress the diversity of idea generation, as well as the disclosure of and advocacy for new ideas in creative project teams (Langfred, 2004), as some team members may cede responsibility for parts of the problem to trusted colleagues and monitor them less. Finally, a more nuanced interpretation of the relationship between credibility and team creativity was provided by Bidault and Castello (2009 and 2010), who demonstrated that very low or very high cognitive trust amongst team members can limit team creativity, while a moderate level of trust enhances creative performance, by inducing an appropriate balance between the acceptance and criticism of expressed ideas.

We subscribe to this idea to explain our counterintuitive result regarding the non-significant relationship between credibility and virtual team creativity, as our measurements do not permit to assess the level of cognitive trust developed between virtual team members, but only to confirm its presence.

5.4 Knowledge sharing and team creativity

Knowledge sharing has a relatively weak but positive relationship with Team creativity, which confirms the central role of this team-level process for new idea generation (Gong et al., 2009; Hargadon and Bechky, 2006; Paulus, 2010). This result clearly indicates that the existence of a functional TMS is often not enough for achieving team performance, requiring the effective implementation of other team processes to access, mobilize, exchange, integrate, and apply the available cognitive resources to the problem faced by the team (Cao and Ali, 2017; Huang and Chen, 2018; Li, Hao and Ren, 2015). The low statistical strength of this relationship may be explained by the need to include in the model other socio-cognitive processes – that may mediate the relationship between Knowledge sharing and Team creativity. Two such potential process are absorptive capacity and knowledge integration, which fully mediate the positive relationship between knowledge sharing and team creativity in the study of Men et al. (2019).

6. Implications

6.1 Theoretical implications

Our findings have several theoretical implications for virtual teams' work, knowledge management, and creativity.

Although communication plays a clear and central role in TMS' development and functioning (Liao et al., 2012; Peltokorpi and Hood, 2019; Ren and Argote, 2011; Yan et al., 2021), the specific influence of the main communication dimensions – volume, frequency and quality - on TMS components is often neglected in empirical papers. Complementing the findings of Yoo and Kanawattanachai (2001) regarding the role of communication volume for TMS development in virtual teams, our study confirms the relevance of communication frequency and quality for the effective development of the three TMS components. However, it is important to note that communication frequency does not have a significant association with knowledge specialization - as this is often a pre-existing condition and/or criterion for recruiting digital team's members. Our study also indicates that communication frequency and quality have an important role not only for the development phase of the TMS – as demonstrated by Kanawattanachai and Yoo (2000) for task-oriented communication, but also for the subsequent maintenance and functioning of its components. However, further research is necessary to fully validate this assumption with longitudinally designed projects. Future studies can also investigate the frequency and quality of communication in relation to the performance of specific channels and methods of digital communication.

Another significant contribution to the TMS literature is the confirmation that knowledge sharing is not an implicit part of the TMS concept, representing an independent intra-team process. This latent controversy is determined by some authors (Huang and Chen, 2018; Huang and Hsieh, 2017; Liu et al., 2019; Ren and Argote, 2011) who include knowledge sharing among TMS' internal functions or processes: "groups with a well-developed TMS exhibit differentiation where different members specialize in learning, remembering and sharing different knowledge" (Ren and Argote, 2011, p. 193) or "the TMS process focuses on knowledge sharing, coordination and exchange between team members" (Huang and Chen, 2018, p. 93). However, other authors clearly differentiate between TMS components, processes and functions, and knowledge sharing, by using both variables in their empirical models (Chen et al., 2013; Choi et al., 2010; Simeonova, 2018). Based on our findings, we posit that TMS represents a socio-cognitive framework for organizing and managing intra-team knowledge, that offers and enhances the potentiality of knowledge sharing and application, but which does not cover the process of creative knowledge exchange.

According to our findings, knowledge sharing is, however, directly influenced by two of the three TMS components. The counter-intuitive result regarding the relationship between coordination and knowledge sharing indicates the necessity to further clarify the conceptual definition and measurement of coordination, in order to better differentiate between its 'state' and 'process' aspects. On the other hand, in line with other extant studies, our research outlines the specificity of virtual teams regarding knowledge exchange coordination, and especially the role of IT support systems and knowledge sharing mechanisms in facilitating team members' contribution and interaction.

Our findings also address the controversy regarding the direct or mediated influence of TMS components on team's performance (in this study defined as team's creativity), outlined by Austin (2003). Extant TMS research presents two alternative models – some authors considering a direct influence of TMS on team's performance (Cabeza-Pullés, Gutierrez-Gutierrez and Llorens-Montes, 2018; Gino et al., 2009 and 2010; Huang and Hsieh, 2017), while others propose a relation between TMS and team performance mediated by teamwork processes (Hsu et al., 2012), team engagement (Guchait, 2016), knowledge sharing (Tsai et al., 2016) or knowledge transfer (Wang et al., 2018).

Our study mitigates this dichotomy demonstrating that TMS' components have both a direct and a mediated effect on team's creativity. Empirical results indicate that two TMS components have a significant direct impact on team's creativity – i.e., specialization and coordination, while the effect of credibility is mediated by knowledge sharing. The non-significant relationship between credibility – or cognitive trust – and creativity represents a fertile ground to challenge the extant theoretical models that link cognitive trust to positive team outcomes. As a number of researchers have demonstrated (Bidault and Castello, 2009 and 2010; Porac et al., 2004; Skilton and Dooley, 2010) a high level of cognitive trust developed amongst team members who worked a long time with each other may diminish the so-called “creative abrasion”, reducing intra-team criticism, and consequently, the creative performance. From this perspective, the dominant positive interpretation of the cognitive trust-creativity relationship should be revisited and further nuanced, in order to understand in what type of teams, projects and organizational contexts cognitive trust may quantitatively or qualitatively limit the creative output.

6.2 Managerial implications

The management of virtual teams can be more challenging than the coordination of collocated teams. To create proper conditions for members’ collaboration, knowledge sharing and creativity, team leaders should identify, understand and address the specific challenges raised by team’s virtual process.

The central role of communication frequency and quality for TMS development requires virtual team leaders and organizational managers to provide a normative framework for formal interactions, occasions for informal discussions and the technical IT infrastructure necessary to ensure frequent and high-quality communication among virtual team members. However, since the frequency of communication has a non-significant relationship with the specialization of knowledge within the virtual team, the team leader should open the intra-team communication flow with a general presentation message, outlining the extant expertise and experience of team members. This initiative may facilitate the mapping of knowledge domains and the further specialization within the team, as most members will probably continue to develop their extant are of expertise.

Once the team’s TMS is developed and becomes functional, it represents a useful tool to quickly identify, access and transfer the relevant knowledge detained by different team members to achieve the defined team’s task. However, to take full advantage of these socio-cognitive resources, the team leader must organize team processes that offer team members effective opportunities to share their knowledge and contribute to the completion of collective task. As our empirical model demonstrates, to enhance team creativity, knowledge sharing activities must be implemented using appropriate IT platforms, tools and applications to facilitate interaction and knowledge contribution from geographically dispersed team members. Although virtual teams lack the advantage of face-to-face communications, in some cases this can represent an advantage, as these teams are forced to implement asynchronous modes of communication that may reduce the speed of the creative process, but which allow more flexibility, requiring a lower level of intra-team time and content coordination. During knowledge sharing sessions, the extant team knowledge is presented, discussed, assessed and processed, leading to novel ideas that are gradually refined and transformed into creative propositions.

Our findings outline the potential negative effects of high cognitive trust and familiarity on virtual team creativity. When the team has functioned in the same formation for a long time, or when some members know each other from other projects, the 'creative abrasion' amongst team members may diminish, as the level of criticism and idea divergence is lowered, leading to an insufficient creative performance. Team leaders can avoid this by monitoring the level of intra-team confidence and familiarity, and attempting to preserve it to a moderate level; in other words, to develop sufficient interpersonal trust to facilitate team members' interaction, but not too much confidence to destroy the dynamism of the creative process based on the confrontation between different personal ideas, opinions and interpretations. On the other hand, the specific techniques of collective brainstorming sessions can be complemented with the critical role of a devil's advocate(s) that can be played either by one or several team members, or by an independent group of experts.

7. Conclusion

Addressing several knowledge gaps regarding the development and use of TMS in virtual teams, this study provides important insights regarding the role of communication as a TMS determinant, the importance of knowledge sharing processes for effectively exploiting the cognitive resources embedded into the team's TMS, and the relationship between various TMS components and team creativity.

Most of our hypotheses have been confirmed by the applied statistical tests. However, three research hypotheses have not been confirmed, representing counterintuitive findings in relation to the main body of literature. To make sense of these results, we mobilized alternative theoretical models and studies (Bidault and Castello, 2009 and 2010; Espinosa et al., 2004; Kanawattanachai and Yoo, 2007) that present a more nuanced perspective of the investigated concepts and relationships. These alternative explanations are extremely important to evidence the differences between TMS emergence and team creativity in collocated versus virtual teams. These counterintuitive findings require not only further investigation but also the implementation of specific research standards and managerial practices – that we outlined in the theoretical and managerial implications of our study.

This paper has several limitations that offer several research opportunities. Considering that TMS development and use represents a dynamic process, future studies should employ a longitudinal data collection to identify the existence of critical events and assess the importance of time for the effective functioning of virtual teams. On the other hand, our methodology should be applied to other virtual groups, to enrich and validate our findings, and further clarify the relationship between coordination and knowledge sharing, or credibility and team creativity. Last, but not least, our quantitative approach should be complemented by qualitative studies that can provide a more complete and detailed picture of the complex relationships between virtual team members, the actions deployed to develop a functional TMS, and the processes implemented to exploit and manage knowledge, in order to enhance virtual teams' performance. All in all, given the current global need to understand and improve the function of virtual work in general and virtual teams in particular, this study (re-)opens the door for more research on the field.

References

Al-Alawi, A.I., Al-Marzooqi, N.Y., Mohammed, Y.F., 2007. Organizational culture and knowledge sharing: Critical success factors. Journal of Knowledge Management 11 (2), 22-42.

Alavi, M., Leidner, D., 2001. Review: Knowledge management and knowledge management systems. Conceptual foundations and research issues. MIS Quarterly 25 (1), 107-136.

Alavi, M., Tiwana, A., 2002. Knowledge integration in virtual teams: The potential role of KMS. Journal of the American Society for Information Science and Technology 53 (12), 1029-1037.

Ali, A., Wang, H., Khan, A.N., 2019. Mechanism to enhance team creative performance through social media: A transactive memory system approach. Computers in Human Behavior 91, 115-126.

Amabile, T., 1996. Creativity in Context. Boulder, CO: Westview Press.

Antoni, C., Hertel, G., 2009. Team processes, their antecedents and consequences:

Implications for different types of teamwork. European Journal of Work & Organizational Psychology 18, 253–266.

Argote, L., 1999. Organizational Learning: Creating, Retaining, and Transferring knowledge. Boston, Mass.: Kluwer Academic.

Argote, L., Miron-Spektor, E., 2011. Organizational learning from experience to knowledge. Organization Science 22, 1123-1137.

Argote, L., Ren, Y., 2012. Transactive memory systems: A microfoundation of dynamic capabilities. Journal of Management Studies 49 (8), 1375–1382

Aritz, J., Walker, R., Cardon, P.W., 2018. Media use in virtual teams of varying levels of coordination. Business & Professional Communication Quarterly 81 (2), 222–243.

Ashleigh, M., Prichard, J., 2012. An integrative model of the role of trust in Transactive Memory development. Group & Organization Management 37, 5-35.

Austin, J.R., 2003. Transactive memory in organizational groups: The effects of content, consensus, specialization, and accuracy on group performance. Journal of Applied Psychology 88 (5), 866–878.

Baer, M., 2010. The strength-of-weak-ties perspective on creativity: A comprehensive examination and extension. Journal of Applied Psychology 95, 592–601.

Bagozzi, R., Heatherton, T., 1994. A general approach to representing multifaceted personality constructs: Application to state self-esteem. Structural Equation Modeling: A Multidisciplinary Journal 1 (1), 35-67.

Barczak, G., Lassk, F., Mulki, J., 2010. Antecedents of team creativity: An examination of team emotional intelligence, team trust and collaborative culture. Creativity and Innovation Management 19 (4), 332-345.

Baruah, J., Paulus, P.B., 2009. Creativity in groups: Research on managing groups and teams, Volume 12, (pp. 29–56). Bingley, UK: Emerald Group Publishing.

Belbaly, N.A., Somsing, A., 2016. Knowledge sharing, transactive memory system, and virtual team creativity. In G. Atinc (Rd.), Academy of Management Proceedings (Vol. 2016, No. 1, p. 15649). Briarcliff Manor, NY: Academy of Management.

Bentler, P., Chou, C., 1987. Practical issues in structural modelling. Sociological Methods & Research 16 (1), 78-117.

Berends, H., Van der Bij, H., Debackere, K., Weggeman, M., 2006. Knowledge sharing mechanisms in industrial research. R&D Management 36 (1), 85-95.

Brandon, D.P., Hollingshead, A.B., 2004. Transactive memory systems in organizations: Matching tasks, expertise, and people. Organization Science 15 (6), 633-644.

Brannick, M.T., Roach, R., Salas, E., 1993. Understanding team performance: A multimethod study. Human Performance 6, 287-308.

Bidault, F., Castello, A., 2009. Trust and creativity: Understanding the role of trust in creativity-oriented joint developments. R&D Management 39 (3), 259-270.

Bidault, F., Castello, A., 2010. Why too much trust is death to innovation. MIT Sloan Management Review 51, 33-38.

Bolinger, A.R., Bonner, B.L., Okhuysen, G.A., 2009. Sticking together: The glue role and group creativity. In E.A. Mannix, J.A. Goncalo, M.A. Neale (Eds.), Creativity in Groups: Research on Managing Groups and Teams (pp. 267–289). Bingley, UK: Emerald Group Publishing.

Buisine, S., Guegan, J., 2019. Creativity in virtual teams: bridging the gap between professional wisdom and scientific insights. Creativity Studies 12 (2), 198-210.

Cabeza-Pullés, D., Gutierrez-Gutierrez, L. J., Llorens-Montes, F.J., 2018. Drivers for performance in innovative research groups: The mediating role of transactive memory system. Business Research Quarterly 21, 180-194.

Cao, X., Ali, A., 2018. Enhancing team creative performance through social media and transactive memory system. International Journal of Information Management 39, 69–79.

Cao, W., Xu, L., Liang, L., Chaudhry, S.S., 2012. The impact of team task and job engagement on the transfer of tacit knowledge in e-business virtual teams. Information Technology and Management 13 (4), 333-340.

Carmeli, A. Gelbard, R., Reiter-Palmon, R., 2013. Leadership, creative problem-solving capacity, and creative performance: The importance of knowledge sharing. Human Resource Management 52 (1), 95-121.

Chamakiotis, P., Dekoninck, E.A., Panteli, N., 2013. Factors influencing creativity in virtual design teams: An interplay between technology, teams and individuals. Creativity and Innovation Management 22 (3), 265-279.

Chen, X., Li, X., Clark, J. G., Dietrich, G.B., 2013. Knowledge sharing in open source software project teams: A transactive memory system perspective. International Journal of Information Management 33, 553–563.

Choi, S.Y., Lee, H., Yoo, Y., 2010. The impact of information technology and transactive memory systems on knowledge sharing, application, and team performance: A field study. MIS Quarterly 34 (4), 855-870.

Chompunuch, S., Ribiere, V., Chanal, V., 2019. Team creativity: Systematic literature review. 2019 International Society for Professional Innovation Management (ISPIM) Conference, Florence, Italy, June 16-19.

Cordery, J.L., Soo, C., 2008. Overcoming impediments to virtual team effectiveness. Human Factors and Ergonomics in Manufacturing 18 (5), 487-500.

Corley, K.G., Gioia, D.A., 2011. Building theory about theory building: What constitutes a theoretical contribution? Academy of Management Review 36 (1), 12-32.

Curşeu, P. Schalk, R., Wessel, I., 2008. How do virtual teams process information? A literature review and implications for management. Journal of Managerial Psychology 23 (6), 628-652.

Curşeu, P. Schruijer, S., Boros, S., 2007. The effects of groups' variety and disparity on groups' cognitive complexity. Group Dynamics: Theory, Research and Practice 11 (3), 187-206.

Davis, A., Khazanchi, D., 2006. Mutual knowledge and its impact on virtual team performance. 1st Annual Midwest United States Association for Information Systems Conference (MWAIS-01), Grand Rapids, Michigan, 93-99.

De Jong, B., Elfring, T., 2010. How does trust affect the performance of ongoing teams? The mediating role of reflexivity, monitoring, and effort. Academy of Management Journal 53 (3), 535-549.

DeSanctis, G., Monge, P., 1999. Introduction to the Special Issue: Communication processes for virtual organizations. Organization Science 10 (6), 693-703.

Eisenberg, J., Mattarelli, E., 2017. Building bridges in global virtual teams: The role of multicultural brokers in overcoming the negative effects of identity threats on knowledge sharing across subgroups. Journal of International Management 23 (4), 399-411.

Espinosa, J.A., Lerch, J., Kraut, R., 2004. Explicit vs. implicit coordination mechanisms and task dependencies: One size does not fit all. In E. Salas, S.M. Fiore (Eds.), Team Cognition: Understanding the Factors that Drive Process and Performance (pp. 107–129). Washington, DC: APA Books.

Espinosa, J., Slaughter, S., Kraut, R., Herbsleb, J., 2007. Team knowledge and coordination in geographically distributed software development. Journal of Management Information Systems 24, 135–169.

Fang, Y., Kwok, R., Schroeder, A., 2014. Knowledge processes in virtual teams: consolidating the evidence. Behaviour & Information Technology 33 (5), 486-501.

Faraj, S., Sproull, L., 2000. Coordinating expertise in software development teams. Management Science 46, 1554-1568.

Farr, J.L., Sin, H.-P., Tesluk, P.E., 2003. Knowledge management processes and work group innovation. In L.V. Shavinina (Ed.), The International Handbook on Innovation (pp. 574-586). New York, NY: Elsevier Science.

Feitosa, J., Salas, E., 2020. Today's virtual teams: Adapting lessons learned to the pandemic context. Organizational Dynamics, June 24. Doi: 10.1016/j.orgdyn.2020.100777.

Fiol, C.M., O'Connor, E.J., 2005. Identification in face-to-face, hybrid, and pure virtual teams: Untangling the contradictions. Organization Science 16 (1), 19–32.

Fong, P.S., Chu, L., 2006. Exploratory study of knowledge sharing in contracting companies: A sociotechnical perspective. Journal of Construction Engineering and Management 132 (9), 928-939.

Fornell, C., Larcker, D., 1981. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research 18 (1), 39-50.

Forsyth, D.R., 2006. Group Dynamics (4th ed.). Belmont, CA: Thomson/Wadsworth.

Gabelica, C., Van den Bossche, P., Fiore, S.M., Segers, M., Gijselaers, W.H., 2016. Establishing team knowledge coordination from a learning perspective. Human Performance 29 (1), 33-53.

Garrett, S., Caldwell, B., 2002. Describing functional requirements for knowledge sharing communities. Behaviour and Information Technology 21 (5), 359-364.

Gino, F., Argote, L., Miron-Spektor, E., Todorova, G., 2010. First: get your feet wet: The effects of learning from direct and indirect experience on team creativity. Organizational Behavior and Human Decision Processes 111, 102–115.

Gino, F., Todorova, G., Miron-Spektor, E., Argote, L., 2009. When and why prior task experience foster team creativity. In E.A. Mannix, M.A. Neale, J.A. Goncalo (Eds.), Research on Managing Groups and Teams: Creativity in Groups (pp. 87-110). Bingley, UK: Emerald Group Publishing.

Glick, W., 1985. Conceptualizing and measuring organizational and psychological climate: Pitfalls in multilevel research. The Academy of Management Review 10 (3), 601-616.

Gong, Y., Huang, J., Farh, J., 2009. Employee learning orientation, transformational leadership, and employee creativity: The mediating role of employee creative self-efficacy. Academy of Management Journal 52 (4), 765-778.

Guchait, P., 2016. The mediating effect of team engagement between team cognitions and team outcomes in service-management teams. Journal of Hospitality & Tourism Research 40 (2), 139-161.

Gutwin, C., Penner, R., Schneider, K., 2004. Group awareness in distributed software development. Proceedings of the ACM Conference on Computer Supported Cooperative Work, 72-81.

Hahm, S., 2017. Information Sharing and Creativity in a Virtual Team: Roles of Authentic Leadership, Sharing Team Climate and Psychological Empowerment. KSII Transactions on Internet & Information Systems 11 (8), http://www.itiis.org/digital-library/manuscript/1778.

Hall, H., 2001. Input-friendliness: Motivating knowledge sharing across intranets, Journal of Information Science 27 (3), 139–146.

Han, S.J., Chae, C., Macko, P., Park, W., Beyerlein, M., 2017. How virtual team leaders cope with creativity challenges, European Journal of Training and Development 41 (3), 261-276.

Hargadon, A., 1998. Firms as knowledge brokers: Lessons in pursuing continuous innovation. California Management Review 40 (3), 209-227.

Hargadon, A., 2002. Knowledge brokering: A network perspective on learning and innovation. In B. Staw, R. Kramer (Eds.), Research in Organizational Behavior, 21 (pp. 41-85). Greenwich, CT: JAI Press.

Hargadon, A., Bechky, B., 2006. When collections of creatives become creative collectives: A field study of problem solving at work. Organization Science 17 (4), 484-500.

Hargadon, A., Sutton, R., 1997. Technology brokering and innovation in a product development firm. Administrative Science Quarterly 42 (4), 716-749.

Hayward, P., 2002. A comparison of face-to-face and virtual software development teams. Team Performance Management 8, 39–48

Heavy, C., Simsek, Z., 2017. Distributed cognition in top management teams and organizational ambidexterity: The influence of transactive memory systems. Journal of Management 43 (3), 919–945.

Hinds, P.J., Weisband, S.P., 2003. Knowledge sharing and shared understanding in virtual teams. In C.B. Gibson, S.G. Cohen (Eds.), Virtual teams that work: Creating conditions for virtual team effectiveness (pp. 21-36). San Francisco, CA: Jossey-Bass.

Hollingshead, A.B., 2001. Cognitive interdependence and convergent expectations in transactive memory. Journal of Personality and Social Psychology 81 (6), 1080–1089.

Hollingshead, A.B., 1998. Retrieval process in transactive memory systems. Journal of Personality and Social Psychology 74, 659-671.

Huang, C.-C., Chen, P.-K., 2018. Exploring the antecedents and consequences of the transactive memory system: an empirical analysis. Journal of Knowledge Management 22 (1), 92-118.

Huang, C.-C., Hsieh, P.-N., 2017. Inspiring creativity in teams: Perspectives of transactive memory systems. Journal of Pacific Rim Psychology, 11, 1-14.

Huang, J.C., Newell, S., 2003. Knowledge integration processes and dynamics within the context of cross-functional projects. International Journal of Project Management 21 (3), 167-176.

Hülsheger, U.R., Anderson, N., Salgado, J.F., 2009. Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. Journal of Applied Psychology 94, 1128–1145.

Iacono, C.S., Weisband, S., 1997. Developing trust in virtual teams. In Information Systems – Collaboration Systems and Technology (pp. 412-420). Proceedings of the 30th Annual Hawaii International Conference on System Sciences.

James, L., 1982. Aggregation bias in estimates of perceptual agreement. Journal of Applied Psychology 67 (2), 219-229.

James, L. Demaree, R., Wolf, G., 1984. Estimating within-group interrater reliability with and without response bias. Journal of Applied Psychology 69 (1), 85-98

Jones, N.B., Borgman, R.H., 2007. An exploratory study on knowledge sharing, information technologies and firm performance. OR Insight 20 (4), 10-21.

Joshi, K., Sarker, S., Sarker, S., 2007. Knowledge transfer within information systems development teams: Examining the role of knowledge source attributes. Decision Support Systems 43 (2), 322-335.

Kanawattanachai, P., Yoo, Y., 2007. The impact of knowledge coordination on virtual team performance over time. MIS Quarterly 31 (4), 783-808.

Kauppila, O., Rajala, R., Jyrämä, A., 2011. Knowledge sharing through virtual teams across borders and boundaries. Management Learning 42 (4), 395-418.

Klitmøller, A., Lauring, J., 2013. When global virtual teams share knowledge: Media richness, cultural difference and language commonality. Journal of World Business 48 (3), 398–406.

Kneisel, E., 2019. Knowledge sharing and creation in virtual teams: An integrated framework based on distributed cognition theory and transactive memory systems. In Z. Fields (Ed.), Imagination, Creativity and Responsible Management in the Fourth Industrial Revolution (pp. 186-206). Hershey, PA: IGI Global.

Krauss, R.M., Fussell, S.R., 1991. Perspective-taking in communication: Representations of others' knowledge in reference. Social Cognition 9, 2-24.

Langfred, C., 2004. Too much of a good thing? Negative effects of high trust and individual autonomy in self-managed teams. Academy of Management Journal 47, 385-399.

Leal-Millán, A., Roldán, J.L., Leal-Rodríguez, A.L., Ortega-Gutiérrez, J., 2016. IT and relationship learning in networks as drivers of green innovation and customer capital: Evidence from the automobile sector. Journal of Knowledge Management 20 (3), 444-464.

Leung, K., Wang, J., 2015. Social processes and team creativity in multicultural teams: A socio-technical framework. Journal of Organizational Behavior 36 (7), 1008-1025.

Lewis, K., 2004. Knowledge and performance in knowledge-worker teams: A longitudinal study of transactive memory systems. Management Science 50, 1519-1533.

Lewis, K., 2003. Measuring transactive memory systems in the field: Scale development and validation. Journal of Applied Psychology 88 (4), 587-604.

Lewis, K., Herndon, B., 2011. Transactive memory systems: Current issues and future research directions. Organization Science 22 (5), 1254-1265.

Li, Y.-J., Hao, S.-Y., Ren, X., 2015. The effect of transactive memory system on team performance: The mediating role of knowledge sharing and the moderating role of task complexity. 2015 International Conference on Management Science and Engineering, October 19-22. Dubai, United Arab Emirates.

Liang, D.W. Moreland, R., Argote, L., 1995. Group versus individual training and group performance: The mediating role of transactive memory. Personality and Social Psychology Bulletin 21 (4), 384-393.

Liao, J., Jimmieson, N.L., O'Brien, A.T., Restubog, S.L.D., 2012. Developing transactive memory systems: Theoretical contributions from a social identity perspective. Group & Organization Management 37 (2), 204–240.

Lin, T.C., Hsu, J.S.C., Cheng, K.T., Wu, S., 2012. Understanding the role of behavioural integration in ISD teams: An extension of transactive memory systems concept. Information Systems Journal 22 (3), 211–234.

Liu, Y., Zhou, X., Liao, S., Liao, J., Guo, Z., 2019. The influence of Transactive Memory System on individual career resilience: The role of taking charge and self-promotion. International Journal of Environmental Research and Public Health 16 (18), 3390-3407.

Lovelace, K., Shapiro, D., Weingart, L.R., 2001. Maximizing cross-functional new product teams innovativeness and constraint adherence: A conflict communications perspective. Academy of Management Journal 44 (4), 779–783.

Malhotra, A., Majchrzac, A., 2004. Enabling knowledge creation in far-flung teams: Best practices for IT support and knowledge sharing. Journal of Knowledge Management 8 (4), 75-88.

Marks, M.A., Mathieu, J.E. and Zaccaro, S.J., 2001. A temporally based framework and taxonomy of team processes. Academy of Management Review 26, 355–376.

Martins, L.L., Gilson, L.L., Maynard, M.T., 2004. Virtual Teams: What do we know and where do you go from here? Journal of Management 30 (6), 805-835.

Maynard, M.T., Mathieu, J.E., Rapp, T.L., Gilson, L.L., 2012. Something(s) old and something(s) new: Modeling drivers of global virtual team effectiveness. Journal of Organizational Behavior 33, 342-365.

Men, C., Fong, P.S.W., Luo, J., Zhong, J., Huo, W., 2019. When and how knowledge sharing benefits team creativity: The importance of cognitive team diversity. Journal of Management & Organization 25 (6), 807-824.

McAllister, D.J., 1995. Affect- and cognition-based trust formations for interpersonal cooperation in organizations. The Academy of Management Journal 38 (1), 24-59.

McComb, S.A., 2007. Mental model convergence: The shift from being an individual to being a team member. In F. Dansereau, F.J. Yammarino (Eds.), Multi-level Issues in Organizations and Time (p. 95-148). Oxford, UK: Elsevier Science.

Mitchell, R., Nicholas, S., 2006. Knowledge creation in groups: The value of cognitive diversity, transactive memory, and open-mindedness norms. The Electronic Journal of Knowledge Management 4, 67-74.

Moreland, R.L., Myaskovsky. L., 2000. Exploring the performance benefits of group training: Transactive memory or improved communication? Organization Behavior and Human Decision Processes 82, 117–133.

Mostert, N.M., 2007. Diversity of the mind as the key to successful creativity at Unilever. Creativity and Innovation Management 16, 93–100.

Newell, S., Bresnen, M., Edelman, L., Scarbrough, H., Swan, J., 2006. Sharing knowledge across projects: Limits to ICT-led project review practices. Management Learning 37 (2), 167–185.

Nonaka, P.B., Borucki, C.C., Konno, N., 1994. Organizational knowledge creation theory: A first comprehensive test. International Business Review 3 (4), 337-351.

Pangil, F., Chan, J.M., 2014. The mediating effect of knowledge sharing on the relationship between trust and virtual team effectiveness. Journal of Knowledge Management 18 (1), 92-106.

Paulus, P.B., 2000. Groups, teams, and creativity: The creative potential of idea-generating groups. Applied Psychology: An International Review 49, 237–262.

Paulus, P.B., Brown, V.R., 2007. Toward more creative and innovative group idea generation: A cognitive-social motivational perspective of brainstorming. Social and Personality Compass 1, 248–265.

Paulus, P.B., Dzindolet, M., Kohn, N., 2012. Collaborative creativity - group creativity and team innovation. In M.D. Mumford (Ed.), Handbook of Organizational Creativity (pp. 327–357). New York, NY: Elsevier.

Paulus, P.B., Nijstad, B.A., 2003. Group Creativity: Innovation through Collaboration. Oxford, UK: Oxford University Press.

Penley, L.E., Hawkins, B., 1985. Studying interpersonal communication in organizations: A leadership application. Academy of Management Journal 28 (2), 309-326.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P., 2003. Common method biases in behavioral research: A critical review of the literature and recommended remedies.

Journal of Applied Psychology 88, 879-903.

Porac, J.F., Wade, J.B., Fischer, H.M., Brown, J., Kanfer, A., Bowker, G., 2004. Human capital heterogeneity, collaborative relationships and publication patterns in a multidisciplinary scientific alliance: A comparative case study of two scientific teams. Research Policy 33, 661–678.

Psychogios, A., Alexandris, K., Onofrei, A., 2008. Addressing individual and organizational factors influencing middle managers synthesising role in knowledge creation and diffusion. International Journal of Learning & Intellectual Capital 5 (2), 208-222.

Rego, A., Sousa, F., Pina e Cunha, M., Correia, A., Saur-Amaral, I., 2007. Leader self-reported emotional intelligence and perceived employee creativity: An exploratory study. Creativity and Innovation Management 16, 250-264.

Ren, Y., Argote, L., 2011. Transactive memory systems 1985–2010: An integrative framework of key dimensions, antecedents, and consequences. Academy of Management Annals 5 (1), 189-229.

Rico, R., Sánchez-Manzanares, M., Gil, F., Gibson, C., 2008. Team implicit coordination processes: A team knowledge–based approach. Academy of Management Review 33 (1), 163-184.

Rosen, B., Furst, S., Blackburn, R., 2007. Overcoming barriers to knowledge sharing in virtual teams. Organizational Dynamics 36 (3), 259-273.

Ruey-Jer, B.J., Sinkovics, R.R., Kim, D., 2014. The impact of technological, organizational and environmental characteristics on electronic collaboration and relationship performance in international customer–supplier relationships. Information & Management 51, 854-864.

Siebdrat, F., Hoegl, M., Ernst, H., 2009. How to manage virtual teams. MIT Sloan Management Review 50, 63-68.

Simeonova, B., 2018. Transactive memory systems and Web 2.0 in knowledge sharing: A conceptual model based on activity theory and critical realism. Information Systems Journal 28 (4), 592-611.

Skilton, P.F., Dooley, K., 2010. The effects of repeat collaboration on creative abrasion. Academy of Management Review 35 (1), 118-134.

Smith, A.E., 2001. The role of tacit and explicit knowledge in the workplace. Journal of Knowledge Management 5 (4), 311-321.

Srivastava, A., Bartol, K.M., Locke, E.A., 2006. Empowering leadership in management teams: Effects on knowledge sharing, efficacy and performance. Academy of Management Journal 49 (6), 1239-1251.

Sternberg, R.J., 2006. The nature of creativity. Creativity Research Journal 18, 87-98.

Stewart, K.J., Gosain, S., 2006. The impact of ideology on effectiveness in open source software development teams. MIS Quarterly 30 (2), 291–314.

Stollberger, J., West, M., Sacramento, C., 2017. Group creativity in team and organizational innovation. In P. Paulus, B. Nijstad (Eds.), The Oxford Handbook of Group Creativity and Innovation (pp. 231-252). New York: Oxford University Press.

Suh, A., Shin, K.S., 2010. Exploring the effects of online social ties on knowledge sharing: A comparative analysis of collocated vs dispersed teams. Journal of Information Science 36, 443-463.

Sung, S.Y., Choi, J.N., 2012. Effects of team knowledge management on the creativity and financial performance of organizational teams. Organizational Behavior and Human Decision Processes 118, 4-13.

Taggar, S., 2002. Individual creativity and group ability to utilize individual creative resources: A multilevel model. Academy of Management Journal 45, 315–330.

Tang, F., 2015. When communication quality is trustworthy? Transactive memory systems and the mediating role of trust in software development teams. R&D Management 45, 41-59.

Taylor, A., Greve, H.R., 2006. Superman or the Fantastic Four? Knowledge combination and experience in innovative teams. Academy of Management Journal 49, 723–740.

Thompson, L., 2003. Improving the creativity of organizational work groups. Academy of Management Executive 17, 96–109.

Tiwana, A., McLean, E.R., 2005. Expertise integration and creativity in information systems development. Journal of Management Information Systems 22, 13–44.

Topchyan, R., 2015. Competencies affecting knowledge sharing in virtual learning teams. Knowledge Management & E-Learning: An International Journal 7 (2), 316-333.

Usoro, A., Sharratt, M. W., Tsui, E., Shekhar, S., 2007. Trust as an antecedent to knowledge sharing in virtual communities of practice. Knowledge Management Research & Practice 5 (3), 199-212.

Tsai, Y.-H., Joe, S.-W., Chen, M.-L., Lin, C.-P., Ma, H.-C., Du, J.-W., 2016. Assessing team performance: Moderating roles of transactive memory, hypercompetition, and emotional regulation. Human Performance 29 (2), 89–105.

Wang, Y., Huang, Q., Davison, R.M., Yang, F., 2018. Effect of transactive memory systems on team performance mediated by knowledge transfer. International Journal of Information Management 41, 65-79.

Wang, X., Ji, Z., 2013. The relationship between knowledge heterogeneity and innovation performance of the interdisciplinary teams, Science Research Management 34 (3), 14-22.

Wegner, D.M., 1987. Transactive memory: A contemporary analysis of the group mind. In B. Mullen, G.R. Goethals (Eds.), Theories of Group Behavior (pp. 185-208). New York, NY: Springer.

Wegner, D.M., Giuliano, T., Hertel, P., 1985. Cognitive interdependence in close relationships. In W.J. Ickes (Ed.), Compatible and Incompatible Relationships (pp. 253-276). New York, NY: Springer.

Wei, L.H., Thurasamy, R., Popa, S., 2018. Managing virtual teams for open innovation in Global Business Services industry. Management Decision 56 (6), 1285-1305.

West, M.A., 2002. Sparkling fountains or stagnant ponds: An integrative model of creativity and innovation implementation in work groups. Applied Psychology: An International Review 51, 355–387.

Wickramasinghe, V., Widyaratne, R., 2012. Effects of interpersonal trust, team leader support, rewards, and knowledge sharing mechanisms on knowledge sharing in project teams. The Journal of Information and Knowledge Management Systems 42 (2), 214–236.

Wu, J., Zhao, H., Pan, D., 2016. Effects of different trust on team creativity taking knowledge sharing as a mediator. In J. Chen, Y. Nakamori, W. Yue, X. Tang (Eds.), Knowledge and Systems Sciences: Proceedings of the 17th International KSS Symposium (pp. 44-56). Singapore: Springer.

Yan, B., Hollingshead, A.B., Alexander, K.S., Cruz, I., Jawaid-Shaikh, S., 2021. Communication in transactive memory systems: A review and multidimensional network perspective. Small Group Research 52 (1), 3–32.

Yoo, Y., Kanawattanachai, P., 2001. Developments of transactive memory systems and collective mind in virtual teams. The International Journal of Organizational Analysis 9, 187-208.

Zahedi, M., Shahin, M., Babar, M.A., 2016. A systematic review of knowledge sharing challenges and practices in global software development. International Journal of Information Management 36 (6), 995–1019.

Zhang, L., Guo, H., 2019. Enabling knowledge diversity to benefit cross-functional project teams: Joint roles of knowledge leadership and transactive memory system. Information & Management 56 (8), doi: 10.1016/j.im.2019.03.001.

Zhang, C., Hong, D., Ling, H., 2012. A study on the mechanism of tacit knowledge integration: The role of social ties and transactive memory systems. International Journal of Innovative Computing, Information and Control 8 (8), 5847-5857.

Zhang, R., Wang J., Hao J.-X., 2020. How does knowledge heterogeneity affect transactive memory system in innovation? Evidence from a field study. Journal of Knowledge Management 24 (8), 1965-1985.

Zhong, X., Huang, Q., Davison, R.M., Yang, X., Chen, H., 2012. Empowering teams through social network ties. International Journal of Information Management 32 (3), 209-220.

Zhu, J., 2009. Utilizing Expertise in Work Teams: The Role of Transactive Memory Systems. PhD Thesis, University of Minnesota. Available at: https://conservancy.umn.edu/bitstream/handle/11299/59485/Zhu_umn_0130E_10832.pdf?seq uence=1.

Zhuge, H., 2002. A knowledge flow model for peer-to-peer team knowledge sharing and management. Expert Systems with Applications 23 (1), 23-30.

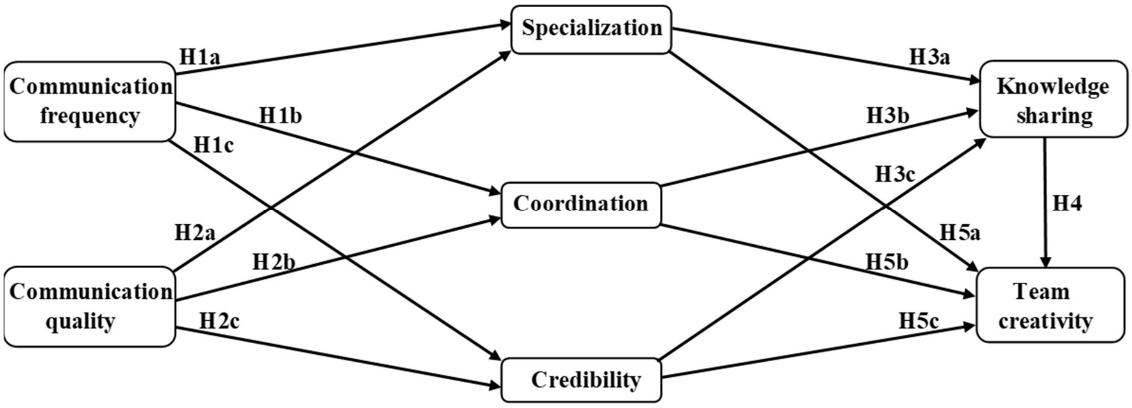

Figure 1. Proposed conceptual model

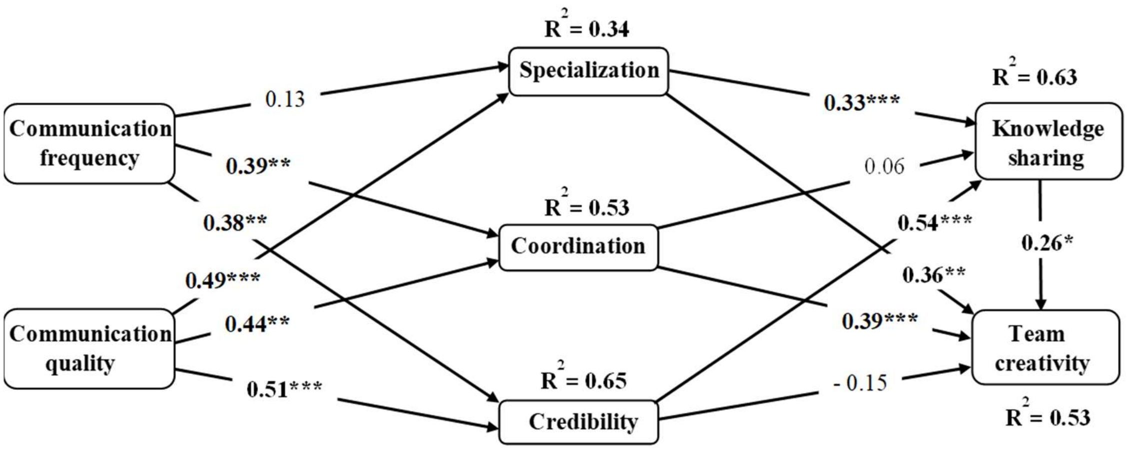

Figure 2. Tested empirical model

Table 1. Discriminant validity of constructs measures

		Factor Analysis						
Constructs	**Items**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Team Creativity (F1)	Cre1	**0.814**	-0.088	0.041	0.078	-0.115	0.021	0.046
	Cre2	**0.847**	-0.076	0.035	0.070	0.071	-0.093	0.003
	Cre3	**0.885**	-0.021	-0.002	-0.033	-0.016	0.027	0.026
	Cre4	**0.796**	0.057	-0.014	-0.037	0.001	0.058	-0.055
	Cre5	**0.839**	0.087	-0.054	-0.028	0.024	-0.018	-0.020
TMS Coordination (F2)	TMSc1	0.114	**0.602**	-0.071	0.048	0.173	0.111	-0.024
	TMSc2	-0.090	**0.923**	-0.081	0.038	-0.014	-0.008	-0.018
	TMSc3	-0.077	**0.867**	-0.002	-0.004	-0.041	-0.017	0.088
	TMSc4	0.168	**0.691**	0.131	-0.073	0.012	0.007	-0.014
	TMSc5	0.010	**0.847**	0.079	-0.013	-0.060	-0.052	-0.041
Knowledge Sharing (F3)	KS2	-0.093	-0.001	**0.826**	0.089	0.045	-0.004	-0.089
	KS3	0.050	-0.022	**0.901**	-0.078	-0.020	-0.019	0.035
	KS4	0.050	-0.014	**0.792**	0.009	0.033	0.023	0.029
	KS5	0.017	0.082	**0.752**	0.026	-0.011	0.035	0.040
TMS Specialization (F4)	TMSa1	0.011	-0.043	0.082	**0.785**	0.086	-0.076	-0.006
	TMSa3	-0.084	-0.003	-0.011	**0.827**	0.029	0.083	0.042
	TMSa4	0.023	0.044	0.014	**0.796**	-0.106	0.041	0.064
	TMSa5	0.098	0.010	-0.044	**0.814**	-0.017	-0.038	-0.099
Communication quality (F5)	CQ1	-0.059	0.135	-0.031	0.024	**0.835**	-0.060	0.021
	CQ2	0.090	-0.070	-0.052	0.017	**0.839**	0.073	0.005
	CQ3	-0.054	-0.082	0.114	-0.041	**0.918**	-0.016	-0.022
TMS Credibility (F6)	TMSb1	0.067	-0.031	-0.058	-0.007	-0.025	**0.894**	0.005
	TMSb2	-0.044	-0.049	0.109	-0.045	0.019	**0.918**	-0.023
	TMSb3	-0.034	0.069	-0.025	0.070	-0.001	**0.803**	0.012
Communication Frequency (F7)	FC1	0.061	0.017	-0.068	0.031	0.197	-0.011	**0.664**
	FC2	-0.002	-0.020	-0.001	-0.107	-0.004	0.041	**0.880**
	FC5	-0.035	0.017	0.046	0.081	-0.110	-0.043	**0.834**
Eigenvalue		10.369	2.076	1.639	1.474	1.280	1.260	1.085
Percentage of variance explained		38.405	46.095	52.167	57.627	62.367	67.035	71.053

Table 2. Team-level descriptive statistics

	1	2	3	4	5	6	7
Team creativity	0.81						
Coordination	0.516^{**}	0.79					
Knowledge sharing	0.408^{**}	0.437^{**}	0.79				
Communication quality	0.410^{**}	0.459^{**}	0.478^{**}	0.80			
5. Specialization	0.533^{**}	0.429^{**}	0.341^{**}	0.329^{**}	0.75		
6. Communication frequency	0.259^{**}	0.408^{**}	0.459^{**}	0.468^{**}	0.183	0.72	
7. Credibility	0.450^{**}	0.518^{**}	0.329^{**}	0.413^{**}	0.432^{**}	0.335^{**}	0.87
Mean	4.61	4.58	4.65	4.81	4.56	4.95	5.00
SD	0.48	0.53	0.48	0.48	0.47	0.68	0.53
AVE	0.66	0.62	0.62	0.65	0.57	0.52	0.76
Cronbach's Alpha	0.90	0.89	0.86	0.84	0.83	0.77	0.91
RWG mean	0.90	0.88	0.87	0.85	0.85	0.75	0.86
ICC1	0.65	0.61	0.61	0.63	0.55	0.52	0.75
ICC2	0.90	0.88	0.86	0.84	0.83	0.77	0.90

Note: AVE= Average Variance Extracted. Diagonal represents square roots of AVEscores. ** $p < 0.01$

Table 3. Structural model fit comparison

χ^2		df	χ^2/df	IFI	CFI	RMSEA	Comparison
Proposed model	434.805	310	1.403	0.932	0.930	0.062	Base model
Competing model 1	457.407	313	1.461	0.921	0.920	0.066	$\Delta\chi^2$=22.602/3df p<0.0
Competing model 2	513.107	313	1.639	0.891	0.889	0.078	$\Delta\chi^2$= 55.7/df p<0.00

Note: Competing model 1 assumes an indirect effect of TMS' manifestations on Creativity via Knowledge sharing; Competing model 2 assumes only a direct effect of TMS' manifestations on Creativity without an indirect effect via Knowledge sharing

Table 4. Results of the structural model

		β	t
Communication frequency	→Credibility	0.38**	3.10
Communication frequency	→Specialization	0.13	0.92
Communication frequency	→ Coordination	0.39**	2.74
Communication quality	→ Specialization	0.49***	3.21
Communication quality	→Credibility	0.51***	4.20
Communication quality	→ Coordination	0.44**	3.27
Specialization	→Knowledge sharing	0.33***	3.30
Credibility	→Knowledge sharing	0.54***	4.74
Coordination	→Knowledge sharing	0.06	0.64
Knowledge sharing	→Team creativity	0.26*	1.70
Specialization	→ Creativity	0.36**	2.95
Credibility	→Creativity	-0.15	-1.03
Coordination	→Creativity	0.39***	3.39
R^2			
Creativity		0.53	
Specialization		0.34	
Coordination		0.53	
Credibility		0.65	
Knowledge sharing		0.63	

Note: *** p < .01; ** p < .05; * p< .10. Two level tested.

Appendix A: Comparison of measurement models

Structure	χ^2	d.f	χ^2/d.f	IFI	CFI	RMSEA	$\Delta\chi^{2a}$	$\Delta\chi^2$/d.f.[a]
Individual Level analyses								
Model 1: Seven-	724.80	303	2.392	0.952	0.951	0.051		
Model 2: Six-Factor	1078.38	309	3.49	0.912	0.911	0.068	353.58	58.93
Model 3: Six-Factor	1280.21	309	4.143	0.889	0.888	0.077	555.41	92.57
Model 4: Six-Factor	1215.61	309	3.934	0.897	0.896	0.074	490.82	81.80
Model 5: Six-Factor	1246.73	309	4.035	0.893	0.892	0.075	521.93	86.99
Model 6: Six-Factor	1151.04	309	3.725	0.904	0.903	0.071	426.24	71.04
Model 7: Six-Factor	1188.56	309	3.846	0.9	0.9	0.073	463.76	77.29
Model 8: Six-Factor	1002.33	309	3.244	0.921	0.92	0.065	277.54	46.26
Model 9: Six-Factor	1104.36	309	3.574	0.889	0.909	0.069	379.56	63.26
Model 10: Six-Factor	1164.72	309	3.769	0.902	0.902	0.072	439.92	73.32
Model 11: Six-Factor	1151.04	309	3.725	0.904	0.903	0.071	426.24	71.04
Model 12: Six-Factor	1325.95	309	4.291	0.884	0.883	0.079	601.15	100.19
Model 13: Six-Factor	1616.22	309	5.147	0.911	0.85	0.088	891.43	148.57
Model 14: Six-Factor combining Co and CQ	1089.80	309	3.527	0.881	0.91	0.069	365.00	60.83
Model 15: Six-Factor	1236.33	309	4.001	0.894	0.893	0.075	511.53	85.26
Model 16: Six-Factor combining Co and TC	1325.95	309	4.291	0.884	0.883	0.079	601.15	100.19
Model 17: One-factor	3090.96	324	9.54	0.684	0.682	0.126	2366.16	112.67

Note: CF = Communication frequency; CQ = Communication quality; S = Specialization; Co = Coordination; C = Credibility; KS = Knowledge sharing; TC = Team creativity

Structure	χ^2	d.f	χ^2/d.f	IFI	CFI	RMSEA	$\Delta \chi^{2a}$	$\Delta \chi^2$/d.f.[a]
Team Level analyses								
Model 1: Seven-	406.99	303	1.343	0.944	0.942	0.057		
Model 2: Six-Factor	501.71	309	1.624	0.895	0.893	0.077	94.72	15.79
Model 3: Six-Factor	514.19	309	1.664	0.888	0.886	0.079	107.20	17.87
Model 4: Six-Factor	535.84	309	1.734	0.877	0.874	0.083	128.86	21.48
Model 5: Six-Factor	514.09	309	1.664	0.888	0.886	0.898	107.10	17.85
Model 6: Six-Factor	499.78	309	1.617	0.896	0.894	0.076	92.80	15.47
Model 7: Six-Factor	491.41	309	1.590	0.901	0.898	0.075	84.42	14.07
Model 8: Six-Factor	453.52	309	1.468	0.921	0.919	0.066	46.53	7.75
Model 9: Six-Factor	514.19	309	1.664	0.888	0.886	0.079	107.20	17.87
Model 10: Six-Factor	578.00	309	1.865	0.854	0.851	0.090	171.01	28.50
Model 11: Six-Factor	492.22	309	1.593	0.900	0.898	0.075	85.24	14.21
Model 12: Six-Factor	616.28	309	1.994	0.833	0.829	0.097	209.29	34.88
Model 13: Six-Factor	469.44	309	0.913	0.891	0.911	0.070	62.46	10.41
Model 14: Six-Factor combining Co and	494.75	309	1.601	0.899	0.897	0.075	87.76	14.63

Note: CF = Communication frequency; CQ = Communication quality; S = Specialization; Co = Coordination; C = Credibility; KS = Knowledge sharing; TC = Team creativity

Appendix B: Questionnaire items

Team creativity (Rego et al., 2007) 1. My team members suggest new ways to achieve goals or objectives. 2. My team members come up with new and practical ideas to improve performance. 3. My team members have new and innovative ideas. 4. My team members promote and champion ideas to others. 5. My team members exhibit creativity when given the opportunity to.
TMS (Lewis, 2003) **Specialization** 1. Each team member has specialized knowledge of some aspect of our project. 2. I have knowledge about an aspect of the project that no other team member has. 3. Different team members are responsible for expertise in different areas. 4. The specialized knowledge of several different team members was needed to complete the project deliverables. 5. I know which team members have expertise in specific areas. **Credibility** (Lewis, 2003) 1. I was comfortable accepting procedural suggestions from other team members. 2. I trusted that other members' knowledge about the project was credible. 3. I was confident relying on the information that other team members brought to the discussion. 4. When other members gave information, I wanted to double-check it for myself. (reversed) 5. I did not have much faith in other members' expertise. (reversed) **Coordination** (Lewis, 2003) 1. Our team worked together in a well-coordinated fashion. 2. Our team had very few misunderstandings about what to do. 3. Our team did not need to backtrack and start over a lot. 4. We accomplished the task smoothly and efficiently. 5. There was no confusion about how we would accomplish the task.
Knowledge sharing (Sue et al., 2010; Suh and Shin 2010) 1. Our team members provide their manuals and methodologies for other team members. 2. Our team members share their experience or know-how from work with other team members. 3. The knowledge shared by team members is helpful to complete my tasks 4. The knowledge shared by team members is accurate
Communication frequency (Penley and Hawkins, 1985) I often communicate with team members online. Our team members communicate online more than face-to-face. Our team members often communicate with different online platforms
Communication quality (Stewart and Gosain, 2006) 1. People on my team answer each other's questions in a timely manner. 2. Team members' responses to each other's questions arc correct and useful. 3. People on my team answer each other's questions in a thoughtful manner.