Does size matter? An investigation into the role of virtual team size in IT service provisioning

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Abstract

Purpose – The purpose of this paper is to investigate the potential influence of virtual team size on team performance by examining group processes in the context of information technology (IT) service provisioning. This paper proposes a theoretical model of the relationships and presents an empirical study to verify the model.

Design/methodology/approach – Utilizing a survey questionnaire as the data collection instrument, this study focuses on IT service provisioning professionals who are actively engaged in virtual work contexts to test the relationships proposed by the theoretical model. A consistent version of the partial least square structural equation modeling (PLS-SEM) approach is used to assess the proposed hypotheses.

Findings – Although the statistical analyses did not provide support for the hypothesized effects of team size on virtual team performance, the results provide novel insights that may help teams overcome the functioning challenges that they face, as reported in the previous literature on virtual team size. In addition, the results highlight the importance of specific group processes for obtaining superior team performance.

Originality/value – Currently, virtual teams are a reality in several organizations, especially in the IT service provisioning industry. However, despite its importance, the literature suggests that virtual team size has not yet been fully explored as a possible means of enhancing group collaboration in such contexts. This paper attempts to provide an empirical contribution to this field using the latest developments in PLS-SEM.

Keywords Team performance, Partial least squares, Survey, Team size, Virtual team

Paper type Research paper

1. Introduction

Virtual teams composed of dispersed team members who are connected through technology are revolutionizing work environments and providing unprecedented levels of flexibility and agility to organizations (Powell *et al.*, 2004; Fan *et al.*, 2014). Given the global and inter-organizational collaborative characteristics of these teams, practices such as the provisioning of information technology (IT) services increasingly rely on such virtual teams (Siakas and Siakas, 2008; Saafein and Shaykhian, 2014). To provide the services required for the maintenance of day-to-day operations of a company's IT systems, virtual teams are leveraged and dismissed according to the need or activity, and the performance of these teams is dependent on the relationships among the team members (Heitlager *et al.*, 2010; Saafein and Shaykhian, 2014).

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Although virtual work can lead to many potential benefits, doubts regarding the performance of virtual teams are common in the literature because the complex task of collaborating is further complicated by this type of work environment (Brahm and Kunze, 2012; Saafein and Shaykhian, 2014). One way to approach this question is to analyze how decisions are made when these teams are structured, such as deciding the virtual team size, which may affect team results. According to Bradner *et al.* (2005), electronic communication aids in maintaining availability and expertise data on teammates through establishing a continuous communication channel between geographically remote participants; therefore, distributed teams commonly include many members. However, more dispersed team members can also create additional challenges for group interactions (Valacich *et al.*, 1994; Leenders *et al.*, 2003; Martins *et al.*, 2004; Lowry *et al.*, 2006; Alnuaimi *et al.*, 2010). Despite its importance, the literature suggests that virtual team size has not yet been sufficiently studied in such contexts (Leenders *et al.*, 2003; Martins *et al.*, 2004; Powell *et al.*, 2004; Bradner *et al.*, 2005; Lowry *et al.*, 2006; Espinosa *et al.*, 2007; Koh and Lim, 2012).

Considering this scenario, this study focuses on virtual teams in the IT service provisioning industry in an attempt to answer the following research question:

RQ1. What is the impact of the virtual team size on a team's performance in terms of the creativity, quality and speed of its collaborative activities?

To this end, a theoretical model is developed and assessed using data collected via a survey of IT service provisioning professionals. A consistent version of partial least squares structural equation modeling (PLS-SEM) is utilized as the statistical analysis method.

The overall structure of the study is as follows. In Section 2, a basic theoretical framework is presented to define the model and its proposed relationships, followed by the hypotheses. Section 3 describes the methods and techniques utilized to support the empirical research. Section 4 describes the results obtained in the statistical analysis and the verification of the hypotheses. In Section 5, the main findings are discussed, followed by the most relevant conclusions and limitations of this study in Section 6.

2. Literature review and the development of the hypotheses

This section presents the basic theoretical framework utilized to obtain the model of the relationships and hypotheses to be assessed subsequently with empirical data.

2.1 Virtual teams

The literature considers virtual teams to be groups composed of geographically dispersed individuals working interdependently with common goals across spatial, temporal and organizational boundaries and utilizing technology to communicate and collaborate (Stough *et al.*, 2000; Duarte and Snyder, 2001; Powell *et al.*, 2004; Qureshi *et al.*, 2006; Fan *et al.*, 2014). However, as highlighted by Martins *et al.* (2004), the definition of a virtual team has recently been focused on the extent of its virtualness, which can vary according to the nature of the task, the technological resources employed, and the skills of the team members. Team dynamics can vary from purely co-located teams who do not require communication technology to completely virtual teams who work without the possibility of face-to-face interaction.

According to Stough *et al.* (2000) and Powell *et al.* (2004), virtual teams are also usually temporary and created on an as-needed basis to cooperate in achieving specific

work deliverables or to attend to a specific need. Therefore, according to Saunders and Ahuja (2006), they are assembled to execute a unique and specific task (or few tasks) to achieve a specific goal. Such tasks are finite, and the virtual teams are dismissed after the goal has been achieved.

IT companies generally tend to utilize virtual teams because they possess both the infrastructure and experience required to support this type of organizational arrangement, i.e., the intense utilization of technology, international interactions and cost restrictions (Stough *et al.*, 2000; Lee-Kelley *et al.*, 2004). In the provisioning of IT infrastructure management services, virtual teams, which are referred to as service teams by Duarte and Snyder (2001), are usually composed of members who are spread around the globe to ensure the continuous operation of the managed IT systems. In this type of service provisioning, because of the frequent interdependence of the activities of different service providers, the practice of building multifunctional teams composed of members from different organizations who collaborate together in specific or non-routine activities is common (Heitlager *et al.*, 2010). This type of team can also be referred to as an action virtual team because of the large extent of its virtualness and transient nature (Duarte and Snyder, 2001); however, for the sake of simplicity, in this study, these teams will be referred to as service or virtual teams whenever mentioned in the IT service provision context. According to Saafein and Shaykhian (2014), the context in which service teams operate can render virtual team challenges more perceptible because troubleshooting a customer's technical problems is inherently complex and challenging.

2.2 Virtual team performance and its antecedents

Despite its advantages, using virtual teams may present several disadvantages, such as challenges in communication, coordination, maintaining remote leadership, managing cultural differences and developing trust relationships among teams. These obstacles may lead to time delays in completing tasks, which, thus, threatens a virtual team's performance (Brahm and Kunze, 2012; Saafein and Shaykhian, 2014). Consequently, virtual team performance has been a focus of many studies.

Studies that analyze virtual team results typically approach the team performance concept by focusing on aspects related to team productivity, such as outcome quality (Fuller *et al.*, 2006; Lee-Kelley *et al.*, 2004), number of ideas (Qureshi *et al.*, 2006) and time required for task completion (Kahai *et al.*, 2012). However, certain researchers, such as Martins *et al.* (2004), suggest that the team performance concept should also be approached through cognitive aspects, such as learning and creativity, which are as important as the former in assessing team performance.

Hackman and Morris (1975) suggest that a key element needed to comprehend team performance resides in the continuous interaction processes developed among the team members. These authors proposed an input-process-output (IPO) framework consisting of the following aspects: the original conditions of the team; the interaction processes; and the team performance. This model is an important research paradigm for studying group work performance. According to Powell *et al.* (2004) and Martins *et al.* (2004), the inputs of the IPO model represent the structural characteristics and composition of the virtual teams that influence the way that these teams operate and execute their tasks. The interaction processes are defined as the ways or methods that the teams utilize to attain their goals, and the outputs represent the consequences of the group functioning. Next, this framework is used to investigate the potential effects of virtual team size on team performance.

2.2.1 Virtual team size. Team size is an integral part of team formation that can be linked to team performance through several theoretical routes. Furthermore, the literature suggests that, as virtual team size increases, managing interactions among members becomes increasingly difficult due to the inherent complexities of interactions among many people (Valacich *et al.*, 1994; Leenders *et al.*, 2003; Bradner *et al.*, 2005; Lowry *et al.*, 2006; Espinosa *et al.*, 2007; Stahl *et al.*, 2009; Alnuaimi *et al.*, 2010; Koh and Lim, 2012).

According to Stahl *et al.* (2009), teams may grow large because larger teams are better able to obtain resources, such as time, energy, money and expertise; however, generally, a group size increase significantly reduces performance and productivity for output quality and quantity. These authors noted that, as group size increases, groups tend to experience more problems in many areas, including communication and cohesion, as an increase in team size increases the number of variables that a team must manage.

Similarly, Valacich *et al.* (1994) and Koh and Lim (2012) note that team size can affect virtual team participation, discussion and collaboration: when the teams include more individuals, more people can participate and contribute; therefore, large team sizes provide a context for more ideas and comments, especially during brainstorming activities. On the other hand, in large teams, the chances of disengagement are greater because members can hide among the group. Therefore, large team sizes are associated with low participation equality (Alnuaimi *et al.*, 2010).

Given this scenario, of particular interest are the effects that team size can have regarding the team's socio-emotional and task-related processes, which refer to the social relationships established among the virtual team members and to the dynamics that occur during the execution of a group's task, respectively (Martins *et al.*, 2004; Powell *et al.*, 2004). The proposed associations among team size, specific group interaction processes and team performance are presented in Figure 1 and further detailed in the next sections.

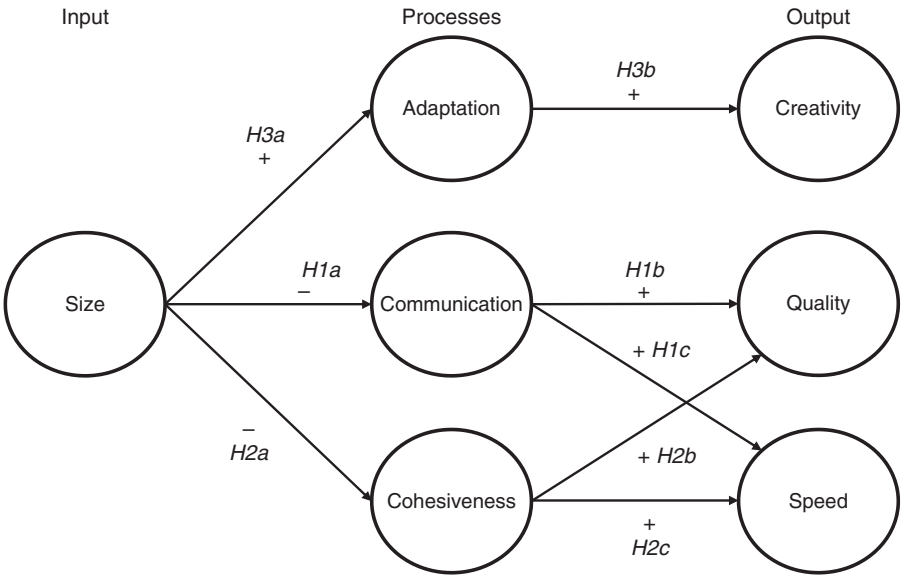

Figure 1.
Detailed model of the relationships and hypotheses

2.2.2 Team size effects on performance via team communication. As highlighted by Qureshi *et al.* (2006), communication plays a central role in virtual team performance and involves not only passing information to a receiver but also properly understanding and using the information. According to these authors, when communication is compromised, group collaboration is ineffective. By contrast, when the communication experience is positive, team members can communicate different perceptions, experiences, knowledge and ideas, which enhances group decision making, creative productivity and efficiency. However, teams that operate in virtual contexts tend to face greater challenges to the orderly and efficient exchange of information due to the intensive use of electronic media to communicate (Powell *et al.*, 2004).

One of the main obstacles to effectively communicating in virtual settings is the technical limitations of communication technologies, especially with regard to information richness, which is critical to building a common language and shared understanding (Martins *et al.*, 2004; Powell *et al.*, 2004). Using a common language is important for a virtual team's performance because it facilitates precise and efficient communication and prevents potential misunderstandings and ambiguity (Lee-Kelley *et al.*, 2004).

Approaching communication processes from a team size perspective, Leenders *et al.* (2003) reported that an increase in the team size leads to the increased centralization of information. These authors suggest that, as the team size increases, the formation of subgroups, which are led by central individuals who are unable to properly integrate and distribute the information, commonly occurs. This can interfere with appropriate communication processes and thus compromise team productivity. According to Riopelle *et al.* (2003), as the virtual team size increases, technological limitations make some communication technologies ineffective. For example, these authors mention that simple communication can become impractical in audio conferences with virtual teams composed of numerous members because maintaining control and focus in the discussion becomes difficult. Similarly, Lowry *et al.* (2006) highlight that although communication technologies can partially mitigate the decrease in quality of communicative processes in larger virtual teams, they cannot totally avoid the losses associated with the precision of the communication, affecting both the quality and speed of decision making. Therefore, the following hypotheses are proposed:

H1a. Increased virtual team size has a negative effect on the communication process among virtual team members.

H1b. A degraded communication process among virtual team members has a negative effect on the quality of work that the virtual team delivers.

H1c. A degraded communication process among virtual team members has a negative effect on the virtual team's delivery speed.

2.2.3 Team size effects on performance via team cohesiveness. Group cohesiveness refers to how attractive the group members find the group and their tasks (Warkentin and Beranek, 1999). According to Brahm and Kunze (2012), a positive link between team cohesion and performance seems intuitively plausible because team productivity should increase if its members feel a certain bond with other team members. In addition, virtual teams with high team cohesion will exhibit more synergetic interactions compared with less cohesive teams. Thus, more effective task-specific communication and workload sharing and fewer conflicts should occur within

significantly cohesive teams. Similarly, Warkentin and Beranek (1999) showed that strong relationship links among virtual team members are associated with positive outcomes, such as better decision making and team member satisfaction. On the other hand, previous research suggests that a lack of psychological proximity among team members can decrease their motivation to execute a group task, potentially deteriorating the virtual team performance (Alnuaimi *et al.*, 2010).

Determining the effects of team size on cohesiveness can be approached from an individual disengagement perspective, as highlighted by Alnuaimi *et al.* (2010). According to these authors, increasing the virtual team size negatively affects individual team member productivity based on three main psychological disengagement mechanisms: diffusion of responsibility, dehumanization and attribution of blame. As the team size increases, the importance of each team member decreases, and, thus, they feel less important to achieving group goals, which leads individuals to reduce their effort. Moreover, as the virtual team becomes larger, establishing interpersonal connections between dispersed team members becomes more difficult, thus reducing the mutual perception of human interaction and causing individual team members to minimize their efforts toward the group task. Lastly, in larger virtual teams, identifying diverse levels of individual effort is easier, which may lead certain team members to blame other members for meager contributions to the team.

Therefore, as virtual teams grow in size, there is a greater possibility of the introduction of cognitive processes that can potentially jeopardize team cohesiveness, thus negatively influencing team member dedication, decision-making quality and satisfaction (Warkentin and Beranek, 1999; Powell *et al.*, 2004; Lee-Kelley *et al.*, 2004; Alnuaimi *et al.*, 2010). In such situations, the potential for making mistakes and failing to meet group task requirements is higher, which increases the time necessary to complete the group task. Therefore, the following hypotheses are proposed:

H2a. Increased virtual team size has a negative effect on the cohesiveness among virtual team members.

H2b. Decreased cohesiveness among virtual team members has a negative effect on the quality of work that the virtual team delivers.

H2c. Decreased cohesiveness among virtual team members has a negative effect on the virtual team's delivery speed.

2.2.4 Team size effects on performance via team adaptation. Adaptation refers to the social, technological and work adaptation process that virtual teams experience as they execute group tasks. Virtual team members learn how to interact with each other, the distributed work environment and collaborative technologies through this process (Powell *et al.*, 2004; Qureshi *et al.*, 2006).

Dennis and Kinney (1998) investigated this process by focusing the task technology fit in virtual teams by associating communication medias richer in physical cues with superior team performance, especially during complex tasks. According to these authors, in this context, this type of communication media facilitates transmission of more detail during communication, which allows team members to communicate faster and better understand complex or ambiguous messages, therefore contributing to superior team performance.

This process is critical for analyzing the potential impact of virtual team size on a team's creative performance. When researchers consider team performance based on the quantity and quality of ideas generated for a particular problem or scenario, the

notion that a group of individuals performs better than a single individual is appealing. A group of individuals interacting with each other can amass different knowledge bases, skills and attitudes, which will lead to more and better quality ideas (Valacich *et al.*, 1994; Leenders *et al.*, 2003; Bradner *et al.*, 2005). However, previous research suggests that this notion only holds if team members can adapt technology to their work through communication technologies and practices that prevent losses during the process (such as production blocking during brainstorming), and promote communication networks with adequate information exchange (Valacich *et al.*, 1994; Leenders *et al.*, 2003, Chang, 2011).

According to Kirkman and Mathieu (2005), large virtual teams naturally facilitate the above scenario. These authors comment that, as the team size grows, fewer opportunities remain for entire teams to synchronously assemble due to logistical problems; therefore, larger teams will more likely employ technology with less informational value (e.g. e-mail) due to difficulties in synchronously assembling all team members, which is necessary for richer tools (e.g. videoconferencing). Therefore, this context would facilitate an alignment between communication media and creative task requirements, supporting greater team creativity (Valacich *et al.*, 1994; Leenders *et al.*, 2003; Chang, 2011). Based on this discussion, the following hypotheses are proposed:

H3a. Increased virtual team size has a positive effect on the virtual team's adaptation for creative tasks.

H3b. Increased virtual team adaptation for creative tasks has a positive effect on the virtual team's creativity.

3. Methodology

Based on the research objective and hypotheses generated from the literature review, this study utilizes a survey questionnaire to collect data to assess the proposed theoretical model.

3.1 Questionnaire design

An electronic questionnaire was posted on the internet to collect the data. The participants were invited to fill out the questionnaire via e-mail. The questionnaire consisted of 50 questions divided into four main sections: an evaluation of the structure of the virtual team, group interaction processes, virtual team performance, and a demographic profile of the respondent. The respondents were instructed to analyze the characteristics of their virtual teams as a whole. In the introduction of the questionnaire, a detailed description of a virtual IT service provisioning team was presented. The respondents had the option to end the questionnaire if the description did not match their current working conditions.

Constructs (except the independent variable, team size) were measured based on the respondents' perceptions using a five-point Likert scale, ranging from 1 (lowest level) to 5 (highest level). Measures were developed based on an extensive literature review using the operational definitions developed, utilized and validated in previous studies. The details of this operationalization process are described below, and measurement scales are provided in Table AI.

3.1.1 Independent variable. Team size. Virtual team size was measured based on the number of team members that the respondents reported. To help facilitate the collection of responses, and consistent with the findings of Chudoba *et al.* (2005), the respondents

were able to choose from four typical team size values: two to five members, six to ten members, 11 to 15 members, and more than 15 members. Therefore, virtual team size was considered a four-level categorical variable and was converted into a formative index of three dummy items, as recommended by Henseler *et al.* (2016), to facilitate its appropriate inclusion in subsequent statistical analyses. "Two to five members" was considered the reference category.

3.1.2 Mediating variables. Communication. The communication processes were measured using the four-item communication precision scale developed by Lowry *et al.* (2006). According to these authors, communication precision reflects the degree to which information is properly communicated and comprehended within the team, i.e., the degree of accuracy and correct understanding of the information conveyed in the group.

Adaptation. Social, technological and work adaptation refers to the appropriate alignment between the technological environment and the activities conducted by the virtual teams (Qureshi *et al.*, 2006). More precisely, it reflects the alignment between the communication technology utilized and the characteristics of the data, information and knowledge exchanges required by the virtual teams. According to Massey *et al.* (2001), this adaptation can be measured by analyzing the team members' perceptions relating to the adequacy of the technology being utilized by the group during a particular communication interaction. Therefore, the eight-item media richness perception scale developed by Dennis and Kinney (1998) was applied.

Cohesiveness. According to Warkentin and Beranek (1999), virtual team cohesiveness reflects the degree of the team members' commitment to other team members and to team goals. It can be measured based on the perceptions of the virtual team members using a five-item scale.

3.1.3 Dependent variables. Creativity. Similar to Gilson and Shalley (2004), the present study measured this variable as the level of creativity applied by the team to achieve the group task. The six-item scale developed by these authors measured the team's propensity to execute group tasks and approach problems in a creative way by gathering different ideas and knowledge bases rather than in a methodical way.

Quality of work. This variable was measured based on the team members' perceptions regarding the quality of the work delivered by their virtual team. According to Fuller *et al.* (2006), the quality of work is a dimension of team performance and can be measured using a three-item scale.

Delivery speed. The delivery speed was measured based on the amount of time it took to complete the activity assigned to the virtual team. Because there were no comparative controls regarding the type of activity executed by the virtual teams, the delivery speed was not measured based on the absolute amount of time that the virtual team required to complete the task. To overcome this constraint, similar to Dayan and Di Benedetto (2010), the present study utilized relative measures, taking into consideration the specific nature of the group task being analyzed. Therefore, the delivery speed was measured based on its comparative assessment with the team's initial planning, company standards, or similar tasks from benchmark companies. To this end, the three-item scale of Dayan and Di Benedetto (2010) was adapted to the context of this study.

3.2 Sample and data collection

The data were collected as a part of a larger survey among IT service provisioning professionals who work in virtual contexts. The targeted respondents of this study were identified from the database of a specialized IT human resources recruiting

company in Brazil, which was hired by the researchers to help disseminate the electronic questionnaire. A total of 94,370 IT professionals were contacted between November of 2013 and February of 2014, and 345 responses were returned. Among these, 139 were valid for the analysis. According to Hair *et al.* (2014), this sample size generally allows for a PLS-SEM analysis to be conducted with statistical power and significance at levels commonly utilized in quantitative research.

Most of the respondents were male (86 percent) and Brazilian (84 percent). Half of the respondents had a bachelor's degree, and another 46 percent reported some form of graduate education. The average age of the respondents was 38 years old. The responses also indicated that, in 72 percent of the virtual teams analyzed, the members had a moderate or high level of previous experience with virtual work. This variable was collected because previous studies indicate that individual competency and experience in virtual work can significantly influence team performance. According to Wang and Haggerty (2011), the emotional skills associated with self-confidence, the technical skills related to the exploration of IT communication tools, and the social skills required to compensate for sparse social interactions in virtual contexts can positively affect group processes and, in turn, the overall performance of the virtual team.

4. Results

Consistent PLS (PLSc) was used to test the theoretical model, because the measurement model is mostly composed by reflective constructs. PLSc represents an important advancement in PLS-SEM that overcomes the previous deficiencies of PLS and maintains its strengths. Among its main improvements, PLSc provides a correction for estimates when PLS is applied to reflective constructs by consistently estimating the path coefficients, construct correlations, and indicator loadings. This correction is required if a model uses reflective measurements, because the traditional iterative PLS algorithm typically underestimates the correlations of reflective indicators while creating proxies as linear combination of observed indicators. Additionally, PLSc provides a global assessment of the model's goodness-of-fit, which makes an assessment of global model fit possible (Dijkstra and Henseler, 2015a, b; Henseler *et al.*, 2016).

The analysis was conducted using the SmartPLS3 software (Ringle *et al.*, 2015) and included both a global assessment (i.e. for the overall model) and a local assessment (for the measurement and structural models) of the model (Henseler *et al.*, 2016).

To measure the appropriateness of the structural assumptions and to identify potential model misspecifications, the model's approximate fit was assessed using the standardized mean square residual (SRMR), which corresponds to the square root of the sum of the squared differences between the model-implied correlation matrix and the empirical correlation matrix (Henseler *et al.*, 2014, 2016; Dijkstra and Henseler, 2015a). A good fit was found between the model and the observed data (SRMR = 0.052, $HI_{95} = 0.094$), as the SRMR value falls below the cut-off value of 0.08 suggested for an adequate fit (Henseler *et al.*, 2016). In addition, the bootstrap-based test of exact fit revealed that more than five percent of the bootstrap samples yielded discrepancy values that were greater than those of the actual model (SRMR $<$ 95 percent bootstrap quantile); thus, the model cannot be rejected (Henseler *et al.*, 2016).

After determining the model's overall goodness-of-fit, the measurement model's reliability and validity were assessed. Table I presents the results for the estimation of the measurement model after the removal of six indicators from the adaptation

construct and two indicators from the creativity construct. These indicators were removed either because they presented outer loadings below the minimum reliability threshold value of 0.40 or because their outer loadings were situated between 0.40 and 0.70 and their removal contributed to an increase in construct reliability and validity (Hair *et al.*, 2014). For each variable, the Cronbach's α, composite reliability (ρ_c), Dijkstra-Henseler's ρ (ρ_A), and average variance extracted (AVE) are presented. For all three reliability measures, the utilized reliability criteria required values exceeding 0.70 (Henseler *et al.*, 2016). For the AVE, the convergent validity criteria required values exceeding 0.50 (Hair *et al.*, 2014). The obtained results confirm the reliability and convergent validity of most of the constructs, except for the creativity construct, which was marginally convergent. All attempts to increase the AVE for the creativity construct, as suggested by Hair *et al.* (2014), failed; however, this construct was kept in the model because there was theoretical support for it and the AVE value was very close to the minimum threshold of 0.50. Table II presents the standardized outer loading values for the reflective indicators in the model.

Table I.
Reliability and validity of the constructs

Constructs	Cronbach's α	Composite reliability (ρ_c)	Dijkstra-Henseler's ρ (ρ_A)	AVE
Adaptation	0.747	0.747	0.747	0.597
Cohesiveness	0.875	0.875	0.880	0.585
Communication	0.820	0.791	0.862	0.507
Creativity	0.797	0.792	0.802	0.491
Quality	0.930	0.930	0.931	0.815
Speed	0.860	0.860	0.878	0.676

Table II.
Item loadings

	Outer loadings					
Indicator	Adaptation	Cohesiveness	Communication	Creativity	Quality	Speed
ADAP5	0.781					
ADAP7	0.764					
COHES1		0.829				
COHES2		0.714				
COHES3		0.689				
COHES4		0.833				
COHES5		0.749				
COM1			0.986			
COM2			0.584			
COM3			0.441			
COM4			0.721			
CREAT2				0.700		
CREAT3				0.799		
CREAT4				0.575		
CREAT5				0.710		
QUAL1					0.938	
QUAL2					0.902	
QUAL3					0.867	
SPEED1						0.767
SPEED2						0.725
SPEED3						0.956

The constructs' discriminant validity was assessed using the heterotrait-monotrait (HTMT) ratio of correlations, which represents the average of the correlations of indicators across constructs that measure different phenomena relative to the average of the correlations of indicators within the same construct. The HTMT criteria have been reported to have superior sensitivity for detecting the lack of discriminant validity compared with standard approaches, such as the Fornell-Lacker criterion, and the assessment of cross-loadings. The most conservative criterion of discriminant validity using HTMT criteria requires values below the threshold of 0.85 (Henseler *et al.*, 2015). Table III presents the HTMT values for each pair of constructs in the measurement model. All latent variables satisfied the HTMT criteria, as all values were significantly smaller than the 0.85 threshold value. Because the HTMT value is an estimate of the correlation between each pair of constructs in the model, if it falls below the 0.85 threshold, then the true correlation between the pair of constructs is most likely different from the value one; therefore, the constructs should differ. This finding confirms the constructs' discriminant validity. Construct correlations are provided in Table AII.

After the quality of the measurement model was sufficient, the structural model could be evaluated. The structural model explained 43.7, 61.4 and 38.6 percent of the variance of the dependent variables of creativity, quality of work and delivery speed, respectively. This model also explained 1.7, 1.4 and 0.1 percent of the mediating variables of adaptation, communication and cohesiveness, respectively. According to Hair *et al.* (2014), these values denote a predictive accuracy that ranges from low (considering the R^2 values of the mediating variables) to moderate (considering the R^2 values of the dependent variables).

The structural model was also submitted to the bootstrapping sampling procedure (1,000 samples) to determine the *t*-values associated with the statistical significance of the model's path coefficients (Hair *et al.*, 2014). The path coefficients (β), their statistical significance and the explained variance (R^2) of the dependent variables are displayed in Figure 2.

Team size did not exhibit statistical significance regarding communication ($\beta = 0.117$, $t = 0.642$, $p = 0.521$); thus, *H1a* was not supported. Communication did not present statistical significance regarding the quality of the work ($\beta = 0.000$, $t = 0.005$, $p = 0.996$) or the delivery speed ($\beta = 0.022$, $t = 0.211$, $p = 0.833$); as a result, hypotheses *H1b* and *H1c* were not supported. Moreover, team size did not exhibit statistical significance regarding cohesiveness ($\beta = -0.037$, $t = 0.270$, $p = 0.787$); thus, *H2a* was not supported. However, the cohesiveness had significant effects on both the quality of the work ($\beta = 0.784$, $t = 11.628$, $p < 0.001$) and the delivery speed ($\beta = 0.610$, $t = 5.658$, $p < 0.001$), supporting hypotheses *H2b* and *H2c*. Lastly, team size did not show

Latent variable	Adaptation	Cohesiveness	Communication	Creativity	Quality	Speed
Adaptation						
Cohesiveness	0.547*					
Communication	0.324*	0.483*				
Creativity	0.654*	0.674*	0.273*			
Quality	0.399*	0.782*	0.379*	0.624*		
Speed	0.396*	0.616*	0.317*	0.587*	0.777*	

Note: *$p < 0.001$

Table III. HTMT criterion analysis

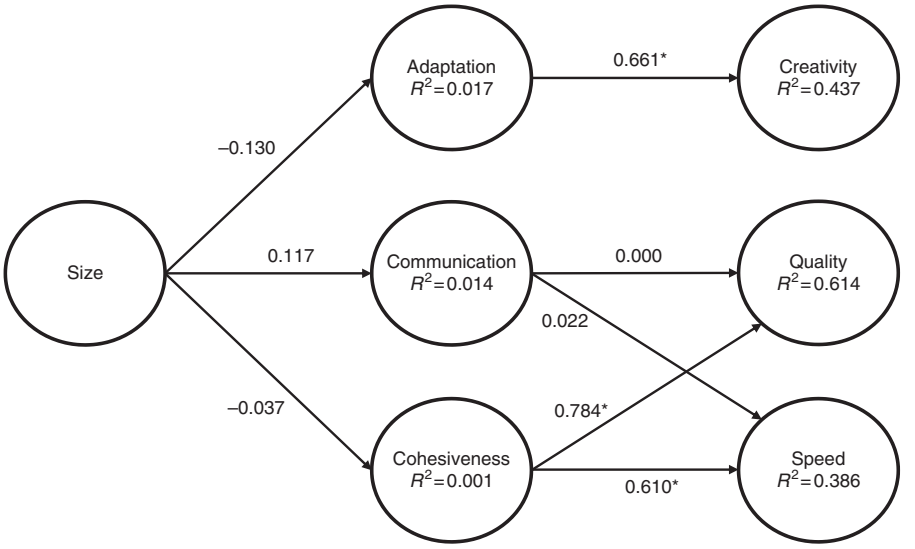

Figure 2.
Path coefficients and the explained variance of the dependent variables

Note: *$p<0.001$

statistical significance regarding team adaptation ($\beta = -0.058$, $t = 0.929$, $p = 0.353$); thus, *H3a* was not supported. However, team adaptation was significantly associated with the team's creative performance ($\beta = 0.661$, $t = 7.962$, $p < 0.001$); thus, *H3b* was supported (Table IV).

The theoretical model also assumed that group processes act as mediators. To check this assumption, an additional test, as suggested by Nitzl *et al.* (2016), was conducted to verify that virtual team size had a direct significant effect on team performance, which would imply that there is partial or no mediation in the model. According to these authors, evidence of the absence of mediation emerges if the

Hypotheses	Result
H1a – Increased virtual team size has a negative effect on the communication process among virtual team members	Not supported
H1b – A degraded communication process among virtual team members has a negative effect on the quality of work that the virtual team delivers	Not supported
H1c – A degraded communication process among virtual team members has a negative effect on the virtual team's delivery speed	Not supported
H2a – Increased virtual team size has a negative effect on the cohesiveness among virtual team members	Not supported
H2b – Decreased cohesiveness among virtual team members has a negative effect on the quality of work that the virtual team delivers	Supported
H2c – Decreased cohesiveness among virtual team members has a negative effect on the virtual team's delivery speed	Supported
H3a – Increased virtual team size has a positive effect on the virtual team's adaptation for creative tasks	Not supported
H3b – Increased virtual team adaptation for creative tasks has a positive effect on the virtual team's creativity	Supported

Table IV.
Test of hypotheses

indirect effect is not significant and the direct effect is significant. The assessment of the direct and indirect paths in the model revealed that both are insignificant, thus suggesting that no direct or indirect effect exists. This result suggests that no mediation exists, as hypothesized in the theoretical model, and that additional reviews of the model may be required.

5. Discussion

Although the results extracted from the studied sample do not suggest any significant statistical relationships regarding the effects that the virtual team size may exert on team performance, some particularities must be carefully considered to obtain a better interpretation of the results.

5.1 Team size effects on performance via team communication

Contrary to initial expectations, team size did not present significant statistical relationships with communication, although the theoretical model predicted that increased team size would damage the precision of communication (Leenders *et al.*, 2003; Lowry *et al.*, 2006). However, such results must be carefully interpreted, especially considering the characteristics of this sample of respondents. According to the descriptive statistics of the studied sample, 72 percent of the respondents declared that their respective teams demonstrated a moderate or high level of previous experience in virtual settings. The higher levels of team members' virtual experience reflected greater virtual social skills and media skills, which would be associated with the team members' greater capacity to establish communication interactions with multiple members and to explore the capabilities of the electronic communication technologies (Wang and Haggerty, 2011). Therefore, these virtual teams should be more inclined to avoid both centralized patterns of information exchange and the utilization of inadequate communication technologies, which can increasingly negatively affect the communication process in virtual settings as the team size increases (Leenders *et al.*, 2003; Riopelle *et al.*, 2003).

Similarly, regarding precision, communication process did not exhibit significant statistical relationships with the quality of work or the delivery speed. According to the theoretical model, when communication is compromised, group collaboration becomes ineffective because there is lack of common understanding among virtual team members (Qureshi *et al.*, 2006). This relationship was not supported, perhaps because of a potential methodological failure in this research, in which the communication construct was measured in terms of the precision of the communicative process. This measure might not be the most appropriate scale for this purpose because common understanding is usually facilitated by the richness of details in the information being transmitted as, for example, when both parties can exchange different perceptions, experiences and knowledge (Martins *et al.*, 2004; Powell *et al.*, 2004). Therefore, the utilization of alternative dimensions to operationalize this construct, such as the richness of details in the communication process, might contribute to increasing the statistical significance of the relationship between team communication and team performance in terms of the quality and speed of the group task being executed.

5.2 Team size effects on performance via team cohesiveness

The results suggest that an increase in virtual team size does not directly affect the level of virtual team cohesiveness. The high level of team members' previous

experience may also contribute to this result. Individuals with more experience in virtual settings are better prepared to handle the uncertainties of executing virtual work and can better recognize other virtual team members' feelings and emotions (Wang and Haggerty, 2011). These behaviors tend to mitigate the cognitive processes that are harmful to group cohesion, such as the processes observed by Alnuaimi *et al.* (2010), and are introduced with an increase in virtual team size.

As expected, cohesiveness had significant statistical effects on both the quality of the work produced by the virtual teams and the speed of delivery. The values of the path coefficients for the relationships between cohesiveness and the quality of work ($\beta = 0.784$) and between cohesiveness and the speed of delivery ($\beta = 0.610$) indicate that decreasing the level of group cohesion by one unit can produce a 0.784 and a 0.610 decrease in the quality and delivery speed, respectively, of the virtual team's work. As a reference, Alnuaimi *et al.* (2010) reported negative path coefficients ranging from $\beta = -0.320$ to $\beta = -0.210$ for the effect of elements relating to the absence of group cohesiveness on virtual team productivity. Therefore, the values obtained suggest that team cohesiveness plays an even more critical role in virtual teams that possess a high degree of virtualness and a transient nature. This result also corroborates and further highlights the importance of group and task attractiveness in obtaining improved virtual team performances, despite the challenges posed by the virtual context in relation to the psychological relationships among team members (Alnuaimi *et al.*, 2010; Powell *et al.*, 2004; Lee-Kelley *et al.*, 2004; Martins *et al.*, 2004).

5.3 Team size effects on performance via team adaptation

Contrary to the initial expectation, team size did not present significant statistical relationships with team adaptation. The theoretical model predicted that larger virtual teams would be more likely to combine the various perspectives and knowledge bases of team members. Additionally, the proper selection of communication technologies was expected to help minimize the centralization of information sharing and production blocking (Valacich *et al.*, 1994; Leenders *et al.*, 2003). Once again, the high levels of previous experience with virtual settings that was observed in the members of the studied virtual teams might have contributed to these unexpected results. Individuals with more experience in virtual settings tend to explore many possible options to overcome problems and persist until they achieve effective electronic communication because they are relatively familiar with the fact that such technologies can facilitate the execution of collaborative activities in virtual settings (Wang and Haggerty, 2011). In this case, the influence of the team size on the process of adaptation can be minimized because the team members should be capable of maintaining an appropriate alignment between the technological environment and the information exchange in the group, despite variations in the size of the virtual team.

Finally, adaptation had a significant statistical relationship with team creativity, as predicted by the theoretical model. This result corroborates previous research suggesting that the virtual team's social work and technological adaptation fosters alignment among work practices, social interactions and technologies, allowing virtual teams to positively explore the cultural differences and experiences of their team members. Furthermore, adaptation allows virtual teams to establish proper communication practices either during brainstorming exercises (Valacich *et al.*, 1994) or other similar group activities that require some form of creativity, such as the analysis of new ideas and the development of innovative approaches and solutions (Leenders *et al.*, 2003).

6. Conclusion

Given the challenges to generating superior performance in virtual settings, this study aimed to analyze whether managing the number of virtual IT service provisioning team member's aids in generating superior performance in terms of creativity, quality and speed of the work. To answer this research question, a conceptual model was developed and assessed using data from a survey and the latest PLS-SEM developments.

Although the results of the statistical analyses do not allow direct inferences regarding the effects of team size on the virtual team's performance, PLS-SEM helped highlight the importance of specific group processes to the virtual team's performance. Regarding team cohesiveness, the results of this study corroborate previous studies that relate group attractiveness to better virtual team outcomes. Moreover, this research suggests that group cohesion and the strength of relationships among virtual team members tend to become more valuable to the virtual team's productivity, as the extent of virtualness and the transient nature of the virtual team increase. Similarly, if these teams can overcome the challenges posed by the considerable extent of virtualness and transience to which they are exposed (by adapting and aligning their work, social and technological needs), very promising perspectives for obtaining superior performance with regard to overall team creativity exist. Despite this main finding, certain important conclusions can also be drawn from the non-significant effects of team size found in this study. The results suggest that team size effects on team performance may be minimized with virtual team members that possess considerable previous work experience in virtual settings. This represents an interesting and novel perspective for research on virtual team size by observing that individual competence may suppress some of the negative aspects associated with larger virtual teams that have been reported in previous studies (Leenders *et al.*, 2003; Riopelle *et al.*, 2003; Lowry *et al.*, 2006; Alnuaimi *et al.*, 2010). Until recently, professionals worldwide were still adapting to this novel way of collaborating at work, which appears to further support the novelty of this perspective (Wang and Haggerty, 2011). Further research is necessary to explore these propositions.

From a group theory perspective, this study supports the applicability of the IPO model in modern forms of organizations, such as virtual teams with large extents of virtualness and transient natures. Additionally, this study contributes to the investigation of a topic that has not been extensively explored: the effect of virtual team size on group processes (Leenders *et al.*, 2003; Martins *et al.*, 2004; Powell *et al.*, 2004; Bradner *et al.*, 2005; Lowry *et al.*, 2006; Espinosa *et al.*, 2007; Koh and Lim, 2012).

From a practitioner's perspective, this study should help virtual team leaders and managers by providing a better understanding of how virtual teams operate and by highlighting the needs that must be considered when structuring such teams, especially in the context of IT service provisioning.

The main limitation of this study is that its generalizability is limited because the theoretical model was based on virtual teams with high degrees of virtual work and transient natures. Therefore, the theoretical model may not apply to other forms of virtual teams, such as permanent teams. Although the methods utilized during data collection and data analysis decreased subjectivity, a potential bias was introduced by the utilization of a non-probabilistic sample. As reported by the research sample, the respondents had considerable previous experience in virtual contexts. Some questions remain with regard to the measurement of the focal construct, i.e., team size; for practical reasons, virtual team size was measured as a categorical variable in this study. However, future studies should attempt to consider team size as a continuous

variable by measuring the actual sizes of the virtual teams (or even a logarithm of the number of team members). Such an approach may contribute additional, and perhaps different, insights that extend the conclusions obtained so far.

Finally, although the research objectives were met, this study was not performed to develop a definitive model or even to exhaust the discussion of the research problem. Many opportunities exist to further develop or enhance the presented theoretical model. Given the absence of statistical significance in many structural paths of the model, future studies should review the theoretical framework presented thus far or consider the inclusion of control variables (such as considerations regarding the type of task and the communication technologies utilized by the virtual teams) in an attempt to identify any potentially missing relationships or mediating/moderating variables. These additional analyses could possibly increase the model's explained variance (R^2) values, which were particularly low for the group processes, and support the mediation role that the literature suggests that these group processes play.

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Appendix 1

Construct	Item
Communication (adapted from Lowry *et al.*, 2006)	The information we received was generally accurate
	We can think of a number of times when we received inaccurate information from others in the group
	It was often necessary for us to go back and check the accuracy of information we received
	We sometimes felt that group members did not understand the information received
Adaptation (adapted from Dennis and Kinney, 1998)	When we disagreed, the communication conditions made it more difficult for us to come to agreement
	When we disagreed, our communication environment helped us come to a common position
	The conditions under which we were communicating got in the way of our sharing of opinions
	We could easily explain things in this environment
	The communication conditions helped us communicate quickly
	We could not easily communicate some ideas to our partners because of the communication conditions
	The communication condition under which we communicated helped us to better understand each other
	The communication condition under which we were communicating slowed down our communications
Cohesiveness (adapted from Warkentin and Beranek, 1999)	Were team members committed to the goals and objectives of the team?
	To what extent was trust exhibited within the team?
	Did members have a strong sense of belonging to the team?
	Did team members recognize and respect individual differences and contributions?
	Were team members open and frank in expressing their ideas and feelings?
Creativity (adapted from Gilson and Shalley, 2004)	Our team was methodical and consistent in the way it tackled problems
	Our team was open to the implementation of new ideas and ways of doing things
	Our team linked ideas that originated from multiple sources
	Our team was persistent in solving a problem even when it took them into areas they knew nothing about
	Our team searched for novel approaches not required at the time
	Our team paid strict regard to the sequences and steps needed to complete a job
Quality of work (adapted from Fuller *et al.*, 2006)	The work produced by our team was high quality
	The activity/task outcome produced by our team was excellent
	The deliverables of our team were outstanding
Delivery speed (adapted from Dayan and Di Benedetto, 2010)	This activity/task was completed in less time than what was considered normal and customary for our industry
	This activity/task was completed on or ahead of the original schedule
	Stakeholders were pleased with the time it took us to conclude the activity/task

Table AI.
Measurement scales used

Appendix 2

Table AII. Construct correlations

Latent variable	Adaptation	Cohesiveness	Communication	Creativity	Quality	Speed	Size
Adaptation	1.000						
Cohesiveness	0.542	1.000					
Communication	0.345	0.516	1.000				
Creativity	0.661	0.685	0.299	1.000			
Quality	0.399	0.784	0.404	0.625	1.000		
Speed	0.394	0.621	0.337	0.594	0.776	1.000	
Size	−0.130	−0.037	0.117	−0.117	−0.042	−0.007	1.000

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