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MEASUREMENT OF GEOGRAPHICAL DISPERSION IN VIRTUAL PROJECT TEAMS

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MEASUREMENT OF GEOGRAPHICAL DISPERSION IN VIRTUAL PROJECT TEAMS

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DEDICATION

This thesis is dedicated to my perfect mother

and supportive father

for their endless

love.

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CONDENSÉ EN FRANÇAIS

La mondialisation et le développement rapide des technologies de communication incitent de plus en plus les organisations à disperser leurs équipes de projets à travers le monde. Cette nouvelle stratégie d'implantation de projets suscite de plus en plus l'intérêt des chercheurs qui s'interrogent sur les facteurs et processus susceptibles de favoriser ce type d'implantation. Or, malgré les nombreuses recherches menées sur ce phénomène au cours de la dernière décennie, certaines dimensions de celui-ci sont toutefois peu explorées, telles que la mesure de la dispersion des équipes de projets. D'ailleurs, les écrits scientifiques rapportent le manque de rigueur et d'homogénéité qui peut exister à ce niveau. Sur la base de ce constat, il s'avère donc intéressant de se pencher sur les mesures de dispersion des équipes, et ce, en analysant celles qui peuvent être potentiellement utilisées dans les équipes de projets réels. Cette analyse fera l'objet de ce projet de recherche.

Toutefois, il est important de souligner le réel défi que peut représenter l'étude de la validité d'une mesure, et ce défi est d'autant plus grand dans le domaine des sciences sociales, car les concepts ne peuvent pas toujours être observés directement. Ils sont souvent construits. Dans le cadre de cette étude, seuls les concepts explicites (tel que la distance), fournis dans une base de données de la Chaire de recherche du Canada en gestion de projet de l'École Polytechnique, sont considérés (Bourgault & Drouin, 2009; Bourgault et al., 2008). Par ailleurs, la question suivante peut alors être soulevée: Parmi les mesures existantes, quelles seraient celles qui seraient susceptibles de mieux cerner la dispersion des équipes?

Pour pouvoir répondre à cette question, les mesures qui ont été sélectionnées dans le cadre de cette étude, sont d'une part analysées à partir d'une base de données contenant plusieurs informations fournies par des professionnels de gestion de projet, et d'autre part, comparées entre elles. La comparaison de ces mesures s'appuie sur un modèle théorique qui décrit le lien qui existe entre 1) la dispersion, 2) l'efficacité des équipes de projets, et 3) certains facteurs

contextuels dont l'influence sur le fonctionnement des équipes est établie par les écrits scientifiques.

De plus, sur la base des résultats de recherche selon lesquelles la dispersion provoque des variations dans l'efficacité de l'équipe, l'hypothèse de recherche suivante peut alors être soulevée: selon une approche analytique, une variation de dispersion serait associée à une variation de l'efficacité du travail en équipe. De ce fait, en étudiant la corrélation qui existe entre ces deux variables, il sera possible de comparer les différentes mesures utilisées pour déterminer le niveau de dispersion des équipes.

Néanmoins, comme le rapporte la littérature, il est important de mentionner que la dispersion en soi, n'est pas la seule variable qui peut exercer un effet sur l'efficacité du travail d'équipe. Tel qu'expliqué au chapitre 2 de ce mémoire, d'autres facteurs contextuels peuvent influencer la relation qui existe entre la dispersion et l'efficacité du travail d'équipe, d'où l'importance de contrôler l'effet de ces facteurs dans cette recherche.

La démarche adoptée pour mener à bien ce projet de recherche est la suivante: dans un premier temps, la problématique et l'état des connaissances portant sur les différentes méthodes de mesure de la dispersion géographique virtuelle sont abordés. Dans un deuxième temps, les mesures qui sont les plus compatibles avec des projets réels et applicables à la base de données existante ont été sélectionnées. Par la suite, ces mesures ont été utilisées sur une base de données de 149 projets. Enfin, en utilisant les données de cette base de données, des tests statistiques, y compris des tests de corrélation, ont été réalisés afin d'analyser: 1) la relation qui existe entre la dispersion et l'efficacité du travail en équipe, et 2) l'effet de certains facteurs contextuels sur la relation entre la dispersion et l'efficacité du travail en équipe.

En ce qui à trait à la collecte de données, la base de données utilisée à cet effet fut construite par l'équipe de recherche de la Chaire de recherche du Canada en gestion de projet à l'École Polytechnique. Ces données ont été recueillies grâce à la collaboration du *Project Management Institute* (PMI) et de l'Association des diplômés HEC Montréal. Le PMI est une association internationale qui 1) regroupe divers professionnels experts en gestion de projet ; 2) établit les normes de bonnes pratiques de gestion ; 3) produit plusieurs publications couvrant des thèmes de recherche en lien avec la gestion ; et 4) offre des certificats d'expertise aux gestionnaires de

projet. Le chapitre PMI de Montréal a fait appel à plus de 2400 professionnels de projet susceptibles de répondre aux critères d'inclusion de cette recherche, c'est-à-dire avoir été impliqués dans une équipe virtuelle, afin de répondre au questionnaire qui leur a été envoyé (plus de détails sur la collecte de données sont fournis par Bourgault et al. (2009)). Le questionnaire ayant été utilisé au cours de cette enquête est présenté en annexe 6.

Afin d'identifier la mesure de dispersion qui correspond le mieux à notre échantillon, et de déterminer s'il s'agit d'une mesure de dispersion simple ou d'une combinaison de deux ou trois indices, des mesures combinées ont alors été créés, et ce, en croisant deux et trois mesures. Les mesures combinées ont l'avantage de permettre l'étude simultanée des différentes dimensions de mesures de dispersion. Chacune de ces mesures cerne une certaine partie de la dispersion globale et la combinaison de ces mesures permet de couvrir une plus grande superficie de la dispersion globale.

Afin de déterminer la meilleure mesure de dispersion, il est important d'identifier d'une part, la meilleure mesure simple et d'autre part les meilleures mesures combinées. Pour ce faire, dans un premier temps, les liens de corrélation pouvant exister entre les variables 1) mesures de dispersion simple, 2) facteurs contextuels, et 3) efficacité du travail en équipe, ont d'abord été étudiées, et ce, en réalisant des tests de probabilité bilatérale et des tests de corrélation de Pearson tel que décrits à la section 4.2.1. Ensuite, la relation qui existe entre la dispersion et l'efficacité du travail d'équipe a été contrôlée par toutes les autres mesures de dispersion telles que présentées par les résultats fournis à la section 4.2.2. De plus, cette relation a également été contrôlée par un facteur contextuel tel qu'expliqué dans la section 4.2.3. Enfin, tel que décrit à la section 4.2.4, la relation des mesures de dispersion avec l'efficacité du travail d'équipe est contrôlée non seulement par toutes les mesures de dispersion, mais aussi par un facteur contextuel. Dans un second temps, les démarches effectuées pour l'étude des mesures de dispersion simple, ont été reproduites pour celle des mesures combinées.

C'est sur la base de l'ensemble de ces analyses, qu'il a été possible d'identifier, parmi les sept mesures simples et les 56 combinés considérées initialement, une seule mesure simple et deux combinées. Parmi toutes les mesures de dispersion simple, les résultats des analyses effectuées rapportent que l'indice appelé *Member Index* est la meilleure solution pour cerner la dispersion.

Parmi les sept mesures de dispersion, une seule est corrélée avec cet indice. Ce résultat peut être en lien avec la maturité des systèmes de contrôle pour gérer la dispersion, mis en place par les organisations technologiques de la présente base de données.

Parmi les mesures combinées, les résultats des analyses révèlent que les deux meilleurs types de mesures de dispersion sont 1) celle qui combine la distance, le temps, et l'indice de voyage, et 2) celle qui combine la distance, le nombre de sites et l'indice de voyage.

Pour conclure, au-delà de la contribution que peut apporter cette étude au plan méthodologique (analyse des mesures de dispersion), cette recherche fournit également des résultats intéressants au plan théorique et pratique. Au plan théorique, cette étude contribue à l'avancement de l'état actuel des connaissances portant sur le thème de la dispersion dont le degré est rarement étudié dans des projets concrets. En effet, bien que certains auteurs aient proposé diverses structures pour cerner cette dimension, les mesures théoriques sont rarement étudiées dans des projets concrets. Afin de pallier cette limite, cette étude explore les mesures proposées, sur la base d'un échantillon de 149 projets réels de la diversité considérable en termes de distance géographique, les fuseaux horaires et les caractéristiques organisationnelles. D'ailleurs les résultats peuvent être utiles aux chercheurs et aux responsables d'équipes virtuelles, au sens où ils prennent conscience de l'aspect multidimensionnel de la dispersion. En effet, Les mesures combinées couvrent de façon simultanée les divers aspects de la dispersion. Au plan pratique, les implications managériales de la thèse telles que l'effet de l'expérience du chef de projet et les compétences managériales, la fréquence de réunions entre les membres des équipes dispersées, et le support technique sont des facteurs essentiels dont il faut tenir compte pour favoriser l'efficacité des projets d'équipe.

RÉSUMÉ

Le contexte actuel de mondialisation et de développement rapide des technologies de communication incite les organisations à mettre en place des équipes de projets dispersées. À mesure que se généralise ce mode d'organisation, plusieurs chercheurs s'y intéressent et tentent de mieux comprendre les facteurs, processus et conditions qui favorisent son implantation. Bien qu'un corpus de connaissances se soit bien développé au cours de la dernière décennie, plusieurs dimensions de ce phénomène restent peu explorées, et c'est précisément le cas de la mesure de dispersion des équipes. La littérature suggère en effet un manque de rigueur et d'homogénéité à ce niveau. L'objectif global de cette étude consiste justement à analyser un certain nombre de propositions de mesure de dispersion appliquées à des équipes de projet réelles.

Après avoir examiné les principales définitions de la dispersion des équipes dans la littérature, certaines mesures sont sélectionnées. Le potentiel de ces mesures est ensuite analysé à partir d'une base de données contenant plusieurs informations fournies par des professionnels de la gestion de projet. La comparaison de ces mesures s'appuie sur un modèle théorique mettant en relation la dispersion, l'efficacité des équipes de projets, et certains facteurs contextuels dont l'impact sur le fonctionnement des équipes est établi dans la littérature.

Au terme de l'analyse, il est possible d'identifier une mesure simple et deux mesures combinées présentant un plus grand potentiel d'applicabilité que les sept mesures simples et 56 mesures combinées considérées initialement. Parmi toutes les mesures de dispersion simple, les résultats des analyses effectuées rapportent que l'indice appelé *Member Index* est la meilleure solution pour cerner la dispersion. Parmi les mesures combinées, les résultats des analyses révèlent que les deux meilleurs types de mesures de dispersion sont 1) celle qui combine la distance, le temps, et l'indice de voyage, et 2) celle qui combine la distance, le nombre de sites et l'indice de voyage.

Outre la contribution sur la plan méthodologique (analyse des mesures de dispersion), cette recherche fournit également des résultats intéressants tant sur le plan théorique que pratique. Plusieurs implications managériales sont identifiées notamment en ce qui concerne l'effet de l'expérience du chef de projet et la fréquence de réunions entre les membres des équipes dispersées.

Au plan théorique, cette étude contribue à l'avancement de l'état actuel des connaissances portant sur le thème de la dispersion dont le degré est rarement étudié dans des projets concrets. En effet, bien que certains auteurs aient proposé diverses structures pour cerner cette dimension, les mesures théoriques sont rarement étudiées dans des projets concrets. Afin de pallier cette limite, cette étude explore les mesures proposées, sur la base d'un échantillon de 149 projets réels de la diversité considérable en termes de distance géographique, les fuseaux horaires et les caractéristiques organisationnelles.

ABSTRACT

The current context of globalization and the fast development of communication technologies encourages organizations to use virtual project teams. As this organizational form is becoming more demanded, many researchers are interested in and try to better understand the factors, processes and conditions that favor its implementation. Although a body of knowledge is well developed over the last decade, several aspects of this phenomenon remain poorly explored, and this is precisely what the measurement of dispersed teams experienced. Indeed, the literature suggests a lack of rigor and consistency at this level. The overall objective of this study is precisely to analyze a number of proposals for measuring dispersion applied to real project teams.

After reviewing the main definitions of virtual teams in the literature, some measures are selected. The potential of these dispersion measures is then analyzed from a database containing information provided by several project management professionals. The comparison of these measures is based on a theoretical model linking the virtual teamwork effectiveness of project teams, and certain characteristics of the organization whose impact on the functioning of the teams were established in the literature.

After the analysis, a simple measure and two combined measures were identified with greater potential applicability of the seven (7) simple measures and fifty six (56) combined measures initially considered. Among all the simple dispersion measures, member index is the best fit to capture dispersion. Among combined measures, the combined measures of spatial, temporal, and travel indices and spatial, number of sites and travel indices are proved to be the best. Besides the methodological contribution (analysis of measures of dispersion), this research also provides interesting results both in theory and practice. Several managerial implications are identified in particular as regards the effect of the experience of the project manager and the frequency of meetings between members of virtual teams.

The current study provides several theoretical contributions to virtual dispersion research community. First of all, the degree of dispersion is rarely studied in real-life projects. Many authors have provided different structures to capture this dimension. However, theoretical measures are rarely studied in ongoing real projects. The present study looks at the proposed measures using a sample of 149 real projects of considerable diversity in terms of geographic distance, time zones and organizational characteristics. The results are of practical use to both researchers and managers of virtual teams.

The concept of creating combined measures to capture the multi-dimensional nature of dispersion is another contribution of this thesis. The combined measures capture the various aspects of dispersion simultaneously.

Among the managerial implications of the thesis, the importance of project manager experience and managerial skills is revealed. The technological support is also a essential factor to consider for project managers.

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LIST OF ACRONYMS AND ABBREVIATIONS

ICT	Information and communication technology
SI	Spatial index
TI	Temporal index
MI	Member index
II	Imbalance index
CI	Categorical index
RI	Travel index
NI	Site index
STR	Combined measure of spatial, temporal and travel indices
SNT	Combined measure of spatial, site and travel indices
ST	Combined measure of spatial and temporal indices
SR	Combined measure of spatial and travel indices
TR	Combined measure of temporal and travel indices
SN	Combined measure of spatial and site indices
NT	Combined measure of site and temporal indices

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CHAPITRE 1 INTRODUCTION

This thesis is one of a series of studies carried out by the Canada Research Chair on Technology Project Management. The research program of this Chair is focused on emerging practices of project management including managing projects in virtual teams. More specifically, this thesis is a continuation of the work of Hamel (2007), Reti (2007), Su (2008), Gervais (2008) and Daoudi (2010), which focused on different aspects of this problem.

1.1 Background of the Study

Virtual or dispersed teams are "small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks" (Ale Ebrahim, Ahmed, & Taha, 2009). The predominance of the role of virtual teams in competitive and fast-evolving world markets is inevitable. Virtual teams are the preferred choice of more than half of companies with 5,000 or more employees and 61% of professional employees have had the experience of working with virtual teams (Martins, Gilson, & Maynard, 2004; Schweitzer & Duxbury, 2010). In a similar vein, in 2012, the Society of Human Resource Management has published the results of a survey filled by its members revealing that 46% of polled organizations were working with virtual teams (Phadnis & Caplice, 2013).

Communication technologies play a key role for multinational organizations operating in fast-evolving global environments. Communication technologies have allowed teams to work virtually and have changed the dynamics between project team members (Berry, 2011). Flexibility has a major role in keeping pace with these changes as teams whose members work face-to-face over the entire life cycle of a project become less and less common. The existence of teams whose members are geographically dispersed as needed requires that the goals of any one project be balanced with other responsibilities (Cummings & Haas, 2012).

The various benefits of working in virtual teams are addressed by different authors. Examples of how virtual work benefits organizations (Ale Ebrahim et al., 2009) include: reduced relocation, time and costs (McDonough, Kahnb, & Barczaka, 2001), reduced time to market (Kankanhalli, Tan, & Wei, 2007; Lipnack & Stamps, 2000), increased flexibility and responsiveness, and

greater team effectiveness and efficiency for companies (Shachaf & Hara, 2005). The search for greater economic efficiency leads to the collaboration of different organizations to realize strategic objectives, given the nature of current competitive markets (Chudoba, Wynn, Lu, & Watson-Manheim, 2005; Maznevski & Chudoba, 2000). These factors have pushed organizations to use virtual project teams as a tool to enable them to be more sensitive in responding to changing markets (Tannenbaum, Mathieu, Salas, & Cohen, 2012).

At the project level, the use of virtual teams is noteworthy in most high tech firms especially in multinationals (Siqueira Ferreira, Pinheiro de Lima, & da Costa, 2012; Wang, Pauleen, & Chan, 2013) .The results of the same survey published by The Society of Human resource Management uncovered that two out of three multinational firms have benefited from global virtual teams (Phadnis & Caplice, 2013). Nevertheless, working with project members in different cities or countries has brought significant challenges to the people and organizations. Some examples of these project management challenges cited by Ale Ebrahim et al. (2009) include: lack of physical interaction (Kankanhalli et al., 2007), conflict management (Hinds & Mortensen, 2005; Piccoli, Powell, & Ives, 2004), and trust issues (Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003). These challenges have pushed the researchers to propose structures and frameworks for handling the complex, dynamic and multifaceted nature of dispersion. Organizations support the virtual teams project members by strategic staffing, training or other effective tools (Drouin & Bourgault, 2013). Resource allocation, coordination and communication support systems are also mentioned as effective tools of top management to support virtual teams (Drouin, Bourgault, & Gervais, 2010).

Schweitzer and Duxbury (2010) considered six (6) initial criteria that defined a team as virtual. These six criteria were geographic dispersion, asynchronicity, temporality, boundary spanning, cultural diversity and communication technology support. They then analyzed whether a team could be considered to be virtual when it fulfilled only one of these criteria and concluded that, as sole criteria, only geographic dispersion and asynchronicity are potentially sufficient to determine dispersion. Finally, they introduced three measures of degree of virtuality—proportion of time spent working virtually, the proportion of members who worked virtually and distance virtuality Despite these contributions, the answer to the question “How virtual are we” posed by Chudoba

et al. (2005), remains limited to some theoretical suggestions. Propositions for reliable dispersion measures validated with real-life projects remain approximate and rare as well.

1.2 Scope of the Research

Broadly speaking, dispersion has several dimensions, including geographic dispersion, cultural dispersion and organizational dispersion. A study of all major dispersion measures was performed in the literature review. However, following this, the scope of the research was limited to geographic dispersion. The study contains objective geographic dispersion measures, which are different from cultural, linguistic, and national dispersion and other kinds of demographic differences. Demographic differences, or social distance, have been found to correlate to geographic dispersion (Martins et al., 2004; O'Leary & Cummings, 2007). It is preferable to study the effects originating primarily from distance rather than demographic differences, which are secondary effects of physical distance. This is consistent with prior research, which relates the challenges of project management more to distance than cultural or national differences (Martínez-Sánchez, Pérez-Pérez, de-Luis-Carnicer, & Vela-Jiménez, 2006). In the current study, geographic dispersion measures are presented within a structure that captures the multi-dimensional nature of dispersion.

1.3 Research objectives

The main objective is comparing various geographic measures proposed in the literature when applied to a sample of real projects, and determining the index that best fits. In order to achieve this goal, several specific research objectives were set:

- To create a database including measures most commonly found in the literature for geographic dispersion.
- To compare a selection of geographical dispersion measures from a conceptual and empirical view.
- To validate the selected measures based on a sample of real-life projects.
- To determine the connection between the selected dispersion measures and teamwork effectiveness considering certain project and organizational contextual factors.
- To recommend the suitable selection of team dispersion measures in future research.

1.4 Document overview

The Introduction chapter presents an overview of the main concepts used in the present study (Chapter 1). First of all, the background of the study is provided. The scope of the research is also presented, and a description of the overall framework and the research objectives are provided. In Chapter 2, an overview of common methodologies and approaches to the definition of virtual teams is provided, based on the literature review. The most common dispersion measures are then presented in detail, as are the conceptual factors that influence virtual teams. Chapter 3 includes the research objectives as well as the conceptual framework for studying the dispersion measures. Chapter 4 is dedicated to presenting the findings. Chapter 5 concludes with a discussion of the key findings of the research and related propositions. Additionally, theoretical and managerial implications useful to both scholars and practitioners based on the main findings of the research are presented. The limitations of the research and recommendations for future studies are also discussed.

CHAPITRE 2 DEFINITIONS, KEY CONCEPTS AND LITERATURE REVIEW

This chapter provides an overview of the literature on virtual project teams. Over the past twenty years or so, researchers have created a community around concepts such as “virtual teams”, “distributed teams”, or “dispersed teams.” The growing interest in this organizational tool reflects changes in industry practices, as an increasing number of organizations operate in a world without geographical boundaries.

The research community is still relatively young but has grown rather rapidly; its boundaries are not yet well defined. This fact is mainly due to the wide variety of disciplines with an interest in the multiple aspects of virtual teams. For example, at one end of the spectrum are researchers interested in the information systems that facilitate knowledge sharing between virtual project teams (Chao-Min, Eric, Fu-Jong, & Yi-Wen, 2011; Li, 2010; Majewski, Usoro, & Khan, 2011), whereas, at the other end, others attempt to explain changes in trust levels over the life cycle of these teams (Bierly, Stark, & Kessler, 2009; Dennis, Robert, Curtis, Kowalczyk, & Hasty, 2012; Gaan, 2012; Liu, Magjuka, & Lee, 2008; V. B. Thomas, 2010). This research draws mainly from the body of knowledge usually covered in this research is management and organizational studies, as well as information systems management.

The present chapter provides a summary of the pioneering work in the field and introduces the main research theme—the study of geographical dispersion measures in virtual project teams. The first section of the chapter (2.1) introduces the various terms used to describe virtual teams and highlights the major studies that attempt to describe the different attributes of these teams. Section 2.2 describes the types of dispersion observed in practice, as described in the literature. The third section (2.3) provides an overview of the main topics addressed by researchers interested in the success factors for virtual teams. Section 2.4 deals specifically with the question of measures of dispersion. It provides an overview of existing studies and identifies the gaps which this research attempts to fill.

2.1 Virtual project teams

Many terms currently exist in practice and in the literature to describe project teams located in multiple sites. It is common to consider the following terms as synonyms: virtual team, dispersed team, distributed team, and collaborative team. All these terms have emerged relatively recently, in the wake of the speed and low cost of data distribution and information and communication technologies (ICTs) via the internet. Analysis of the different articles during the last twenty years revealed the common use of the word “virtual teams” which justifies the choice of this word in the current thesis (Martins et al., 2004).

The definition of virtual project teams has evolved over the years. In the traditional definition, teams were termed “virtual” only when work on the entire project was performed in different locations with concomitant communication, problem-solving and social interaction challenges (Chudoba et al., 2005). As such, they were completely dispersed, so the team was simply classified as either co-located or virtual (Schweitzer & Duxbury, 2010).

The current definition of virtual project teams is more realistic and flexible, describing the degree of virtuality. As such, the modern definition of virtual teams stresses the importance of “extent of virtuality” (Martins et al., 2004). In other words, the definition and the related research questions tend to focus on “how virtual are we” (Schweitzer & Duxbury, 2010) instead of “are we virtual or not”. Virtual can be defined variously (O'Leary & Cummings, 2007; Watson-Manheim, Chudoba, & Crowston, 2002); but most of the time, it would include references to not sharing a common workspace and maintaining contact through such communication and collaboration tools as email and video-conferencing (Schweitzer & Duxbury, 2010). Temporary teams or project teams involving different organizations are the other types of virtual teams defined (Espinosa, Cummings, Wilson, & Pearce, 2003).

In the literature, the concept of virtuality is developed based on different terms. The concept of boundaries was developed by Espinosa et al. (2003) to expand the definition of virtual teams. Boundaries, in his work, were defined as any gap or discontinuity in, or dividing factor of, virtual work including geographic distance, time zones, expertise, politics, and culture.

Discontinuity was the term used by Chudoba et al. (2005) to express team virtuality. She has defined discontinuity as gaps in any aspect of virtual work, such as gaps related to tasks, work methods and relationships with other project members. In the current research, the term "dispersion" is used to capture Chudoba's (2005) notion of discontinuities and Espinosa's (2003) of boundaries.

Definitions of virtual teams also vary based on the field to which they are applied. In information systems (IS), "virtual" is used to express specific constructs such as virtual organizations and virtual teams. Virtual organizations outsource the major components of production (Kraut, Steinfield, Chan, Butler, & Hoag, 1998). A typical structure for an IS virtual team would be ad hoc problem-solving teams comprised of members in different locations (Chudoba et al., 2005; Jarvenpaa, Knoll, & Leidner, 1998).

Of all the criteria to establish team virtuality, geographic distance, time zones, ICT-based communication and organization are those most commonly cited (see Table 2.1). Most definitions include time and geographic distance. Organizational differences and ICT are also common means for measuring virtual dispersion in the literature. Cultural differences and the life cycle of the project are noted by smaller number of articles. A review of the different criteria for virtual dispersion, adapted from Schweitzer and Duxbury (2010), is provided in Table 2.1.

Table 2.1 Review of different criteria for virtual teams (adapted from Schweitzer and Duxbury (2010)

Authors	Distance	Different time zones	ICT-based	Cultural differences	Organizational differences	Life cycle (Temporary)
Lipnack and Stamps (1997)			√		√	
Townsend, DeMarie, and Hendrickson (1998)	√		√		√	
Maznevski and Chudoba (2000)	√		√		√	
Bal and Foster (2000)	√	√	√			√
McDonough et al. (2001)	√			√		
Lurey and Raisinghani (2001)	√	√			√	
Watson-Manheim et al. (2002)	√	√		√		√
Espinosa et al. (2003)	√	√			√	
Martins et al. (2004)	√	√			√	√
Powell, Piccoli, and Ives (2004)	√	√	√		√	√
Hertel, Geister, and Konradt (2005)	√	√	√		√	
Geister, Konradt, and Hertel (2006)	√		√			
Gibson and Gibbs (2006)	√		√	√	√	
O'Leary and Cummings (2007)	√	√				
Bourgault, Drouin, and Hamel (2008)	√	√	√			
Ale Ebrahim et al. (2009)	√	√	√		√	√
D. Thomas and Bostrom (2010)			√		√	
Turel and Zhang (2010)	√	√	√		√	

From the definitions provided above, four main elements of virtual teams are derived. Virtual teams are the teams which are i) geographically dispersed, ii) are extended through different time zones, iii) have ICT-based nature meaning are dependent on technology in order to communicate and iv) have different organizational boundaries.

2.2 Different types of dispersion

The previous section outlined various contributions to defining virtual teams and various types of dispersion that researchers have analyzed in the literature (Sections 2.1 and 2.2). Using these definitions, studies have attempted to identify factors that affect the progress and success of teams working virtually (Section 2.3). Although a large body of literature on managing virtual teams exists today, it is particularly interesting to note that few empirical studies provide a precise functional measure of dispersion, whether spatial, temporal, cultural or other. While it is true that many of the existing empirical studies position dispersion as the background for their research, this variable has little effect on the studies. For example, studies of management teams within a multinational firm may perform a comparative analysis of co-located and virtual teams but they quantitatively do not assess the extent or impact of the dispersion (Schweitzer, 2010; Gibson, 2006). Several approaches of this type are used in experimental or quasi-experimental designs involving groups of students spread across campuses (Hertel et al., 2005; Martins et al., 2004).

The present study addresses this gap by reviewing the measures of dispersion proposed in a few empirical studies and applying them in the real-world context of professionals working in virtual teams. The present study's focus is exclusively on project team member's dispersion. Dispersion is measured in five different ways, namely: i) geographic distance (spatial dispersion); ii) time zone disparity (temporal dispersion), iii) team configuration (configurational dispersion), iv) use of technology to substitute for lack of face-to-face contact and v) cultural dispersion.

Each of these ways are described in detail in certain empirical studies in the sections below (sections 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5).

2.1.1 Spatial dispersion

Spatial dispersion, the geographic distance between virtual project team members, is the dimension that authors most emphasize in studies of virtual teams (Martins et al., 2004). As a result of the widespread desire to use a skilled workforce without taking into account their geographic location, geographic spatial dispersion is common in the literature (O'Leary & Cummings, 2007).

Spatial dispersion is an important consideration, since it reduces spontaneous communication and the probability of face-to-face interactions (Cummings & Haas, 2012; O'Leary & Cummings, 2007; G. Olson & Olson, 2000). The absence of verbal cues and facial expressions stemming from lack of communication leads to various challenges of virtual teams including conflict and trust issues. The effect of geographic distance on conflict challenges in virtual teams was studied by Hinds and Mortensen (2005). To do this, 21 virtual teams and 22 co-located teams within the same company were compared. The aim was to determine whether differences in conflict resolution existed when comparing virtual and co-located teams. They found the virtual teams to be more susceptible to interpersonal conflict challenges and task challenges than the co-located teams. They also found that spontaneous communication is the strategy virtual teams use to manage conflict. The virtual team environment magnifies the role of trust in the achievement of project objectives as well (Kirkman, 2006). Mutual trust can empower communication technology tools and improve project efficiency (Dixon, 2012). A high level of trust at the beginning and end of the project leads to more effective management of uncertainties and complexities throughout the duration of the project (Gaan, 2012). Gaan studied 25 virtual projects over a 57-day period. Panteli and Duncan (2004) tried to study the development of trust in virtual teams by conducting a case study of a successful temporary virtual team. They analyzed some 400 email records related to a specific case-study project. The subjects of these emails were such topics as negotiations with clients and employees, technical queries, and others. They studied the trust level reflected in these emails. While they were successful in analyzing trust levels, they studied only a single organization and their analysis was limited to email analysis, just one tool among many possible communication technology tools.

2.1.2 Temporal dispersion

Temporal dispersion amplifies the consequences of spatial dispersion. Project teams which are extended east-to-west are more subject to problems of asynchronous communication than the project teams extended north-to-south (O'Leary & Cummings, 2007). Temporal dispersion, defined as the time difference between team members, creates real-time problem solving challenges (Herbsleb, Mockus, Finholt, & Grinter, 2000; O'Leary & Cummings, 2007). This kind of dispersion creates the possibility of working in a "world in which the sun never sets" (Ale Ebrahim et al., 2009; Cataldo & Nambiar, 2012)—of working 24 hours a day. However, many authors stress the scheduling, coordinating and task-monitoring challenges that arise due to different rhythms in communication exchanges and asynchronous communication (Chudoba et al., 2005; Espinosa & Carmel, 2003; Saunders, Van Slyke, & Vogel, 2004). Information flow management is made more difficult by asynchronous interaction and temporal dispersion causes an increase in misunderstandings and errors (Marcelo Cataldo, Bass, Herbsleb, & Bass, 2007; Cataldo & Nambiar, 2012; Ramasubbu, Cataldo, Balan, & Herbsleb, 2011).

Despite the fact that temporal dispersion is common in the literature, this term is often used interchangeably with spatial dispersion. A structured method for measuring temporal dispersion was first provided by O'Leary & Cummings (Colazo & Fang, 2010).

2.1.3 Configurational dispersion

Many authors suppose that the two dimensions of spatial and temporal dispersion are insufficient measures of geographic dispersion. Configurational dispersion is related to arrangement of people in sites not the geographic distance between them. An increase in the number of sites would lead to an increase in the number of dependencies of the sites to be managed. This increased number of dependencies is due to one of the following two factors—an increased number of roles and responsibilities or the duplication of technical tasks performed in the different sites. An increased number of project sites also means international integration, which brings with it other forms of dispersion, specifically cultural and organizational, making management processes more difficult (Cataldo & Nambiar, 2012).

An uneven dispersion of project team members can cause a feeling in team members who are in the minority of being “out of the loop” or having a “big brother”. This leads to more conflict and reduced awareness (Cataldo & Nambiar, 2012; O'Leary & Cummings, 2007). Team member isolation is an extreme effect of an unbalanced arrangement of team members across locations (Cataldo & Nambiar, 2012).

O'Leary and Cummings (2007) emphasized the importance of arrangement of project team members in sites. They stated that more coordination challenges would exist in the project with the greater number of sites. This fact led to the introduction of the number of sites as a measure of geographic dispersion. They also emphasized the importance of imbalance index. For example, if two project teams in two sites are considered, each at the same geographic distance and crossing the same number of time zones but with one difference: in the first project the members are equally distributed, with five people in first site and five in the second; the second project, however, has one person in the first site and nine in the second. In the first situation, project team numbers are balanced. In the second, the distribution of project team members is highly unbalanced, isolating the single individual and possibly leading to majority influence and conflict between project team members. This example underlines the importance of three elements of configurational dispersion: the number of sites; the imbalance index, or unevenness of project team member dispersion across all sites and the isolation index.

Many researchers mention the importance of configurational dispersion but few have measured its elements (Baba, Gluesing, Ratner, & Wagner, 2004). O'Leary and Cummings (2007) were the first authors to provide a structured method for measuring configurational dispersion. However, they did not apply their measures to real-life projects and it remained as theoretical framework.

2.1.4 Organizational dispersion

Organizational dispersion is the other kind of dispersion which has been studied by many researchers. This kind of dispersion entails differences in skill levels, division of labour and practices (Knoben & Oerlemans, 2006). Integrating project team members from different organizations with different strategic objectives gives rise to communication challenges and influences group dynamics (Daoudi, 2010; Maznevski & Chudoba, 2000). Organizational

dispersion includes two distinct categories, intra-organizational and inter-organizational dispersion. Intra-organizational dispersion refers to the affiliation of members of a project team with different project work groups or departments. Inter-organizational dispersion involves project-team members affiliated with different organizations (Daoudi, 2010; Knoben & Oerlemans, 2006; Watson-Manheim et al., 2002). Functional and business concerns that differ due to the strategic values of different organizations are considered to be challenges for virtual project teams (Chudoba et al., 2005; Orlikowski, 2002). This kind of dispersion may interfere with other types of dispersion, including spatial distance, and amplify collaboration challenges (Chudoba et al., 2005; Espinosa et al., 2003).

2.1.5 Cultural dispersion

With the increasing tendency to use international project teams, cultural dispersion is inevitable in the new era of globalization.

Culture has been variously defined by many authors, making it difficult to provide an integrated definition (Daoudi, 2010). Often defined as the “mental collective programming” shared by a certain group or community of people (Hofstede, 2001), culture is an important factor of diversity and is very much associated with virtual teams. Differences in communication modes, values and attitudes towards authority are just some of the many dimensions that may impact virtual teamwork (Lim and Liu, 2006; Chudoba et al., 2005).

Cultural dispersion can lead to the creation of subgroups. Project team members who are emotionally attached to their formed subgroups are a major cause of tension involving other project team member cultural subgroups (Shore et al., 2009).

In many studies, cultural dispersion has demonstrated its impact on decision making processes (Chudoba et al., 2005), conflicts and anxiety (Lim & Liu, 2006), misunderstanding and mistrust (Bal & Foster, 2000), as well as on collaboration (Shachaf & Hara, 2005).

2.2 Contextual factors that influence virtual teams’ functioning

Martins et al. (2004) were the first to methodically study the various dimensions and factors influencing virtual teams’ functioning using an inputs-processes-outcomes model (I-P-O). They

based their research on an I-P-O framework to study and analyze the various factors that affect virtual teams (Bourgault & Drouin, 2009). Within this framework, all fundamental and natural team characteristics are classified as team inputs, dynamic interactions and processes are considered to be team processes and consequences and benefits are team outcomes.

Inputs are representatives of design or compositional characteristics of the team (Martins et al., 2004). As team inputs, Martins et al. (2004) mentioned team size, knowledge, skills and abilities (KSA), technology, task, composition, diversity, member characteristics, leadership and organizational context.

Team processes included planning (tasks such as analyzing the mandate and setting strategic objectives), action processes (coordination, knowledge transfer, alignment of technology with tasks and monitoring) and interpersonal relations (with conflict, informality, cohesiveness, group identity and trust as subcategories. As team outcomes, they considered member satisfaction, time required, performance, knowledge management, team creativity and team learning (Bourgault & Drouin, 2009; Martins et al., 2004).

These concepts can be classified under four main categories: i) characteristics related to the nature of the project; ii) characteristics related to project team members; iii) characteristics related to ICT and iv) characteristics related to the organization. The following sections provide an overview of each category.

2.2.1 Characteristics related to the nature of the project

- Project team size

Project team size has been proven to be a salient factor in teamwork quality (Espinosa, Slaughter, Kraut, & Herbsleb, 2007; Hoegl, 2005; Hoegl & Proserpio, 2004; Muethel, Siebdrat, & Hoegl, 2012). Hoegl (2005) stressed the importance of team size to different aspects of teamwork quality, including the sharing of technical and coordinating information: the larger the team, the greater the communication challenges. Among these was the increased difficulty of coordinating member contributions from different sites. They concluded that balancing member contributions was critical to larger teams since team members tend to expend less effort when working in larger teams. Espinosa et al. (2007) studied the challenges of team size and dispersion. In larger project

teams, the dependencies between project team members increase and the challenge of coordination is more significant. The ability to communicate is also influenced by team size, so communication occurs through many channels. They found team size to have a negative impact on teamwork effectiveness.

- Project manager experience and managerial skills

Project manager experience and skill becomes more critical as geographic dispersion increases and, as it increases, the challenges of communication and coordination should be more carefully managed (Hoegl & Proserpio, 2004). Hoegl and Proserpio (2004) analyzed the effect of project management skills on teamwork quality. The project manager's experience is a significant factor in the relation between dispersion measures and teamwork effectiveness (Bourgault & Drouin, 2009). Tannenbaum et al. (2012) focus on the fact that the project manager's experience and managerial skills are critical to a project's success when reviewing work and communicating at a distance. Fisher and Fisher (1998) describe the role of team leader or project manager as resembling that of a local area network connecting intelligent computers. The role of the project manager is to virtually use the team members' knowledge. They mention some competencies required of the project manager, including the ability to aggressively eliminate barriers to team effectiveness (an indicator of authority) and coach individuals and teams effectively (leadership attributes) (Bal & Teo, 2001a).

- Similarity of work methods

The fundamental role played by similar work methods is clear, given the fact that different members of a project team have varying perspectives on how a job should be done (Chudoba et al., 2005; Lu, Watson-Manheim, Chudoba, & Wynn, 2006). This issue adds to the complexity of decision making (Harvey, Novicevic, & Garrison, 2004), miscommunication (Cramton & Orvis, 2003) and conflict (Chudoba et al., 2005; Mannix, Griffith, & Neale, 2002). Chudoba et al. (2005) investigated the effect of varying work methods on teamwork effectiveness and concluded that a variety of practices negatively impacted performance. Lu et al. (2006) noted that several aspects of performance are impacted by a variety of work methods, including communication and trust between team members.

2.2.2 Characteristics related to virtual project team members

Prior common experience of team members, called a subcategory of “team familiarity” in the literature, attracted the attention of some authors (Espinosa et al., 2007; Huckman, Staats, & Upton, 2009). Team familiarity is defined as “the knowledge that members of a team have about the unique aspects of their work” (Goodman & Garber, 1988). This general concept of familiarity is studied on two levels: task familiarity, which occurs as team members work together and share common knowledge about the task, and team familiarity, shared knowledge about other team members.

Team familiarity can be expressed as “team members’ prior experience working with one another” (Staats, 2012). Prior common team member experience mitigates the coordination challenges caused by geographic dispersion by reducing communication demands (Espinosa et al., 2007). Huckman et al. (2009) examined how the changing composition and structure of teams impact their performance. They noted that prior common team member experience has a positive effect on team performance. They also discovered its role in managing the challenges posed by task changes and interpersonal team diversity. Staats (2012) proposed two dimensions for team familiarity. He considered hierarchical team familiarity, that is, the “manager’s experience with front-line team members” and horizontal team familiarity, defined as “front-line team members’ experience gained with each other”. The results of his research show that horizontal team familiarity has a more significant (positive) impact on performance than hierarchical team familiarity. In other words, project team members’ past relationships have a strong positive impact on performance.

2.2.3 Characteristics related to the organization

- Organizational support

Organizational support is a combination of the training provided by the organization and technology provided to equip the team for virtual work. Training is proposed by Hertel et al. (2005) as a means of handling diversity, to increase team cohesiveness and satisfaction (Ale Ebrahim et al., 2009). Different training levels and processes are discussed. Training in the efficient use of communication technologies in kick-off meetings is mentioned in Hertel et al.

(2005), referring to a German article written by that author and other colleagues who examined the effects of training on team effectiveness in 10 virtual procurement teams in a large company. They confirmed the positive effects of training on clarity of team objectives and the effective use of communication media. Various other kinds of training, including meeting training, project management skills and technology training, are mentioned by Bal and Teo (2001b) in an exhaustive methodology of different dimensions of virtual team work. Thomson, Perry, and Miller (2009) studied the role of organizational support on the success of virtual teams, stressing the importance of creating shared norms and regulations in virtual team management. They also mention a structured administrative system to support clear roles and responsibilities and improved communication and monitoring of virtual project activities.

- Face to face meetings

Fostering social links between project team members in virtual teams with face-to-face and virtual meetings is critical. However, the question of whether face-to-face or virtual meetings are crucial to teamwork effectiveness is still controversial. Many authors have emphasized the use of mixed modes of interaction, that is, both face-to-face and virtual meetings (Dubé & Pare, 2004; J. S. Olson, Teasley, Covi, & Olson, 2002). Crowston, Howison, Masango, and Eseryel (2007) focused on the importance of face-to-face meetings as a tool for maintaining social ties between virtual project team members by increasing the speed of interaction during the performance of some tasks and providing an opportunity for social time. In their article, they proposed that this type of communication can have an effect on social ties including trust, shared understanding, and group cohesion. They also noted that creating social ties at a distance can be a difficult task. Maznevski and Chudoba (2000) focused on the importance of a regular pattern of face-to-face meetings to the effectiveness of virtual teams.

2.2.4 Characteristics related to information and communication technology

- Virtual meetings

Virtual meetings involving groups of participating students in laboratories are often held empirically via text communications and there are few reports on technology-supported spoken interactions such as video conferencing (Anderson, McEwan, Bal, & Carletta, 2007).

The performance of video-supported teams was proven to be as good as those who held face-to-face meetings, with the difference being that virtual teams spent more time clarifying how to manage their work. Researchers concluded that audio communication alone is not efficient (Anderson et al., 2007; Olson, Olson, & Meader, 1995). Anderson (2006) also analyzed the problem-solving process of virtual teams and the face-to-face interactions of co-located teams and found the same common ground was attained in both cases.

- Technological support

Technology has already proven its potential for enhancing teamwork effectiveness (Tannenbaum et al., 2012), however, technological improvements can be a challenge to teams. For example, in some cases the use of video cameras provides the possibility of seeing other team members at all times, but increased monitoring could be perceived as "big brother" intrusiveness, causing distrust.

2.3 Measuring geographical dispersion

Geographic dispersion is measured in many different ways. Many dispersion measures have been investigated in the context of experimental and quasi-experimental student projects and laboratory studies; oftentimes involving graduate students (Martins et al., 2004; Schweitzer & Duxbury, 2010; Staples & Webster, 2008). Few studies have reported measuring the degree of dispersion from real setting. The observation of Chudoba et al. (2005) regarding the need for dispersion measures to assess the degree of virtual dispersion in real-life projects resulted in a study of current dispersion measures. Measures validated by real-life projects fall into four main categories:

- Spatial dispersion
- Temporal dispersion
- Configurational dispersion
- ICT-mediated dispersion

A complete review of the articles measuring dispersion using a real-life context, excluding experimental settings such as those using students as subjects, is provided in Appendix A. In this

selection, major dimensions of dispersion are extracted including spatial dispersion, temporal dispersion, configurational dispersion and ICT-mediated dispersion. They are presented in subsequent sections (2.3.1, 2.3.2, 2.3.3, and 2.3.4).

2.3.1 Spatial dispersion

Spatial dispersion is studied in literature review with various methods. Using the Likert scale, percentage or mathematical formula are the examples of how spatial dispersion is calculated. In the present section, the question of how spatial dispersion is calculated is responded by the use of some empirical studies.

O'Leary and Cummings (2007) proposed to measure spatial dispersion by considering geographic distances between sites, weighted by the number of team members in each site. Cataldo and Nambiar (2012) studied spatial dispersion using O'Leary and Cummings (2007) measures and archival data from 189 projects in a company that produced embedded systems for the automotive industry. Hinds and Mortensen (2005), with a final sample of 43 teams and a total of 288 respondents, included spatial dispersion as a physical distance between teams and in order to measure that they used self-reported data of each member location. They concluded that shared identity, shared context and spontaneous communication all moderated the relationship between spatial dispersion and conflict.

Cummings and Haas (2012) used a seven-point scale to capture increasing levels of physical separation in measuring geographic dispersion. The points on the scale were: 1-same room; 2-different room; 3-different hallway; 4-different floor; 5-different building; 6-different city and 7-different country. The study group was comprised of 2055 members of 285 teams in a large multinational corporation. They concluded that geographic dispersion did not have any moderating effect on team allocation and team performance.

Schweitzer and Duxbury (2010) conducted research with 107 team members from 30 different teams within a large private-sector organization that analyzed the effect of degree of virtual dispersion on traditional measures of teamwork effectiveness. “Degree of separation” was introduced, considering the scores for the distance between hypothetical meeting points and the

site of each project. The results of their study showed that the degree of separation negatively impacts teamwork effectiveness attributes.

Degree of co-location is also a dispersion measure based on the concept of distance (Montoya, Massey, Hung, & Crisp, 2009). It was applied to survey data from 184 respondents on 15 teams from three sectors—design and manufacturing, information systems and construction. They considered four co-location categories for project team members: <25%; 25-50%; 50-75% and 75-100% co-location.

Staples and Webster (2008) studied the moderating effect of different dispersion measures on trust and knowledge sharing, and teamwork effectiveness and knowledge sharing, using a survey of 824 virtual team members. They created structures based on distance and classified teams in these structures based on team members' location: all members co-located (a traditional team); all members remote (a virtual team) or a combination of both, with some members co-located and some remote (a hybrid team). They found a moderating effect on knowledge sharing and teamwork effectiveness only in the hybrid teams. In teams with a hybrid structure, the relationship between knowledge sharing and team performance was very weak.

Espinosa et al. (2007) used a dichotomized variable to measure geographic dispersion. The data for their study was collected from archival data on software development teams involved in software production at a large telecommunications firm. Since there were only two sites in the study, if all project members (software developers) were located in the same place, the dichotomy was 0 and otherwise it was 1. The results revealed that geographic dispersion and team size have a negative impact on teamwork effectiveness, but team members' prior common experience mitigates the negative impact.

Hoegl and Proserpio (2004) measured team members' proximity based on the four following statements: most members of my team worked directly in the vicinity, so they can visit each other without much effort; team members were located too far from one another to move the project along expeditiously; only a few team members were easily reachable on foot; it was at times problematic to get the team members together in one place for spontaneous meetings (e.g., for discussions and decisions). Data came from the responses of 430 participants from 145 software development teams. Results showed that team members' proximity had a positive impact on

work quality. Hoegl, Ernst, and Proserpio (2007), with 575 respondents from 145 software development teams, used the same dispersion measures but went beyond the analysis of the effect of dispersion alone on teamwork quality performed in 2004. In their work they analyzed dispersion as a "determinant of teamwork quality, which in turn affects team performance." Their research showed that the positive impact of teamwork quality on both team effectiveness and team efficiency in innovative projects increases with team members' decreasing proximity. So, with an increase in geographic dispersion, team work quality would not only be more difficult to achieve, but also more critical and vital to team performance.

Cramton and Webber (2005) assessed geographic dispersion by coding teams into one of two categories following interviews with team leaders: (1) teams with co-located members whose members all work out of the same office and (2) teams with geographically dispersed members, in which at least 30% of the members work out of offices at one or more locations separate from the others. The data for the research came from a survey of 218 respondents on 39 work teams (international consulting firm specializing in the delivery of customized software and systems integration). The study revealed less effective work processes for virtual teams compared to co-located teams. They also noted a significant negative relation between geographic dispersion and perceived performance.

As the above discussion demonstrates, authors have used different methods to measure spatial dispersion. The majority used qualitative dispersion scales which take into account different levels of spatial dispersion, but do not quantify the degree of dispersion numerically. Others, however, focused on expressing the degree of dispersion using numbers. Measuring the exact degree of dispersion allows researchers to get a closer fix on the level of virtuality of a project team and produces more effective studies.

2.3.2 Temporal dispersion

Temporal dispersion is also measured in various ways based on time zone or time spent working virtually. O'Leary and Cummings (2007) have measured temporal dispersion with the different time zoned, weighted by the number of team members in each site. Cataldo and Nambiar (2012) studied temporal dispersion based on the measures of O'Leary and Cummings (2007) and

concluded that temporal dispersion negatively impacts software quality. Hinds and Mortensen (2005) also used O'Leary and Cummings (2007) temporal dispersion measures and concluded that temporal dispersion is related to conflict.

Colazo and Fang (2010) studied temporal dispersion with an actual-work-hour based method using archival data from 100 development teams (open-source system project teams). Temporal dispersion in their work was measured "using the variance in the team members' starting time," where time was determined using a location-independent time unit, UTC (coordinated universal time). In each case "the time when each developer submitted his first contribution was recorded." The results showed temporal dispersion to be positively associated with development speed and quality of coding. Furthermore, the relationship between temporal dispersion and quality of coding is moderated by the software's structural complexity.

Schweitzer and Duxbury (2010) developed a time-based measure called "proportion of teamwork time spent virtually." This measure is defined as the proportion of hours members spent working virtually out of all their hours spent on team tasks. Proportion of time spent working virtually significantly correlated (negatively) with two measures of effectiveness—satisfaction and team members' perception of virtual performance.

Staples and Webster (2008) studied a time-based measure called time-zone spread. It is defined as the extent to which one needs to collaborate with team members in different time zones, based on Chudoba et al. (2005). The data to validate this measure came from an online survey of 824 participants. They observed no moderating effect of time-zone spread on trust and knowledge sharing or on knowledge sharing and performance. Use of only a Likert scale to measure temporal dispersion is not an exact method for this task.

Considering the literature on temporal dispersion provided in this section, different methods are found to measure temporal dispersion that demand extra effort to extract pertinent information. In some cases, like the one of Colazo and Fang (2010), these measurements require the analysis of an organization's entire employee database. Furthermore, the labor laws in each country, including shift hours, are different and this causes many problems in normalizing the results. In the other cases, like the one of Schweitzer and Duxbury (2010), measuring temporal dispersion

also requires the exact monitoring of the number of hours that each project team member spends working virtually.

2.3.3 Configurational dispersion

As already mentioned in section 2.1.3, configurational dispersion has different dimensions including number of sites, imbalance or people dispersion. In order to measure this kind of dispersion, various methods are used in literature. In a site index study performed by Cataldo and Nambiar (2012) based on measures from O'Leary and Cummings (2007), the number of sites was found to have a negative impact on software quality. They also introduced a people-based dispersion measure based on the entropy measure to assess configurational dispersion. Team member dispersion was also found to have a negative impact on software quality. Hinds and Mortensen (2005) also used the O'Leary and Cummings (2007) site index.

Schweitzer and Duxbury (2010) studied a measure called proportion of member virtuality. This measure was calculated as the total number of different member locations divided by the number of team members and multiplied by 100. Proportion of member virtuality was significantly negatively correlated to perceived losses in performance quality.

In their work, based on O'Leary and Cummings (2007), Staples and Webster (2008) used an imbalance index equal to the standard deviation of members per site divided by the size of the team. No moderating relationship between trust and knowledge sharing was found. However, the imbalance index had a moderating effect (negative) on the relationship between knowledge sharing and performance. They also studied the isolation index expressed as the percentage of team members who are alone or with one other team member at a site (O'Leary & Cummings, 2007). The results showed no moderating effect on the relationship between trust and knowledge sharing or between knowledge sharing and performance.

Configurational dispersion is measured in a structured way in the empirical studies validated with real-life projects. This facilitates the measurement of this dimension of dispersion.

2.3.4 ICT-based dispersion

ICT-based dispersion is mesaured more in qualitative way and quantitavitive methods rarely exist in literature. Bierly, Stark and Kessler (2009) expressed dispersion by degree of team member interaction using computer and telecommunications technologies (from face-to-face to fully virtual). A three-item measure on a 5-point Likert scale (Cronbach's alpha = 0.78), was used to capture this dimension. "We primarily interacted through computer and telecommunications technologies" was a questionnaire item. This study sample was made up of 116 respondents representing 116 new-product development teams. Greater degrees of virtuality were found to exacerbate the negative association between relationship conflict and trust, reduce the importance of goal clarity in creating trust among members and render trust less important in facilitating cooperation in new product development (NPD) team members.

Stark and Bierly Iii (2009) also conceptualized dispersion by the extent to which team members interacted through computer and telecommunications technologies, as in Bierly, Stark and Kessler (2009). The sample for this study was made up of 178 respondents representing 178 new product development teams. The results showed that with increased virtual dispersion, group work was preferred and relationship conflict had a greater negative impact on member satisfaction. Goal clarity and familiarity were not moderated by the degree of virtualness, but did have a significant direct effect on member satisfaction.

Gibson and Gibbs (2006) measured dispersion using four items and a 5-point scale (1 = not at all; 5 = to a very great extent) to etablish the extent to which members relied on three forms of electronic communication (e-mail, teleconferencing, and collaborative software), as well as their overall reliance on electronic communication.

The literature review confirms that there is still a lack of quantitative methods to measure ICT-based dispersion. Use of Likert scale for measuring this kind of dispersion is a proof to this issue.

2.4 Critical notices

The lack of exhaustive measures for geographic dispersion is responsible for "lack of clarity on what we know and the direction that future research should take," noted by Martins et al. (2004) (Schweitzer & Duxbury, 2010). Based on the literature, quantification of the degree of

geographic dispersion is still rare (Gibson & Gibbs, 2006; Schweitzer & Duxbury, 2010) and geographic dispersion is rarely studied in real-life projects. Dispersion measures are often simplistic, e.g., percentage of co-location (Montoya et al., 2009); creation of team categories (co-located, virtual, and hybrid teams) (Staples & Webster, 2008); use of simple point scales (Cummings & Haas, 2012).

O'Leary and Cummings (2007) provided a structure that includes a spatial index, a temporal index and configurational indices to measure the critical dimensions of geographic dispersion, but that study was theoretical and they did not use any empirical data. Examination of theoretical measures has rarely been done to date. Moreover, in literature, the structured methods to compare dispersion measures are rare.

Schweitzer and Duxbury (2010) proposed three dimensions of proportion—teamwork time spent virtually, member virtuality and degree of separation—to measure geographic dispersion. However, to validate their proposed measures, they used data from just a single organization. Conducting the research in only one organization and in one region largely reduces the reliability of dispersion measures studied. The sample size of 30 teams was another weakness, limiting the value of the data analysis and the ability to generalize from the results.

In the present thesis, the selected measures of dispersion, based on the literature review, were validated using a database of 149 real-life projects in different fields. Use of a database with the vast variety of projects, fills the void in validation of dispersion measures with vast multi-organizational projects.

CHAPITRE 3 RESEARCH DESIGN

This chapter details the main steps taken in this empirical study. First, the research objectives and strategy are explained in Sections 3.1 and 3.2. The conceptual framework is then presented in Section 3.3, with subsections covering dispersion measures (3.3.1), contextual factors (3.3.2) and teamwork effectiveness (3.3.3). Section 3.4 discusses data collection procedures, and data analysis is discussed in Section 3.5.

3.1 Research objectives

The lack of a comprehensive definition of geographic dispersion and a mechanism for its measurement which is validated with real-life projects has caused difficulties in the research environment (Schweitzer & Duxbury, 2010). In order to help push the limits of the current body of knowledge, more emphasis is needed from a methodological perspective, which is to improve the validity of the measures to be used.

The general objective of this research is to provide a better understanding of which measure of dispersion best captures geographic dispersion in real-life projects. This measure is either a simple measure or the combined measure that integrates different concepts of dispersion at the same time. Consideration of combined measures provides a wider vision on dispersion. Within this general goal, the specific objectives are:

- to survey the most common measures used in the literature to measure geographic dispersion of virtual teams.
- to compare a selection of key measures from a conceptual and empirical standpoint.
- to examine the value of the selected measures based on a sample of real-life projects.
- to analyze potential connections between the selected dispersion measures and teamwork effectiveness, considering certain project and organizational contextual factors.
- to make recommendations on the selection of team dispersion measures for future research.

3.2 Research strategy

Determining the validity of a measure has always been a real challenge in science in general. In the case of social science in particular where many concepts cannot be observed directly but are constructed, this challenge is even greater. In the case of this particular study, the choice was made to use only explicit concepts (eg. distance, etc.) for which data was available in an existing database compiled by the Canada Research Chair in Project Management at the École Polytechnique (Bourgault & Drouin, 2009; Bourgault et al., 2008). Still, the question remains as to what measure would best capture the dispersion of teams.

The basic hypothesis of the research is the following. On the basis of previous research (chapter 2), it has been proved, although with some limitations, that dispersion does cause some variations in teamwork effectiveness. In other words, and from an analytical perspective, it means that a variation of dispersion would be associated with a variation of teamwork effectiveness. Starting with this hypothesis, it would then be possible to compare various ways of measuring dispersion by observing their correlation indices with teamwork effectiveness.

This approach needed to be complemented by a second one which would take into account the fact that, as proposed in the literature, dispersion per se may not be the only factor influencing teamwork effectiveness. As indicated in Chapter 2, many contextual factors may come into play, and this is why this study needed to control for these factors when investigating the relationship between dispersion and teamwork effectiveness.

We can recap all the research process as follows: First, the literature was reviewed to identify different methods of measuring virtual geographic dispersion. Following this, the measures which were most compatible with real-life projects and applicable to the existing database were selected. Thereafter, these measures were used on a database of 149 real-life projects. Statistical tests, including correlation tests, were performed on this database to analyze: i) the relationship between dispersion and teamwork effectiveness, and ii) the impact of certain contextual factors on the relationship between dispersion and teamwork effectiveness.

3.3 Data collection

For the collection of data, the database was built by the research team of the Canada Research Chair in Project Management at the École Polytechnique. Data from real-life projects were collected from two sources. The first sample was built in co-operation with the Montreal Chapter of the Project Management Institute (PMI). The PMI is an international association of project management professionals that sets standards for good practices, produces publications and certifies expertise in the field. The Montreal PMI agreed to distribute a questionnaire with was sent to over 2,400 project professionals who could potentially meet the research criteria, that is, having been or being involved in a virtual team. The second data source was the HEC Montreal Alumni Association. More details about data collection is provided in Bourgault et al. (2009). The questionnaire that was used during that survey is provided in Appendix F. Some references to that questionnaire also appear in the next sections of this chapter.

3.4 Conceptual framework

The conceptual framework for this study consists in three elements—dispersion measures, certain project and organizational contextual factors and teamwork effectiveness. As mentioned in literature review, dispersion measures studied in this thesis are extracted from three main types of dispersion, spatial dispersion, temporal dispersion and configurational dispersion (See section 2.1). The current dispersion measures include spatial, temporal, number of sites, travel, member, imbalance, and categorical indices. The contextual factors related to project, project team members, organization and technology (ICT) are also derived from literature (See section 2.2). Figure 3-1 shows the model studied, showing the relation of dispersion measures to teamwork effectiveness and the role contextual factors play in this relationship.

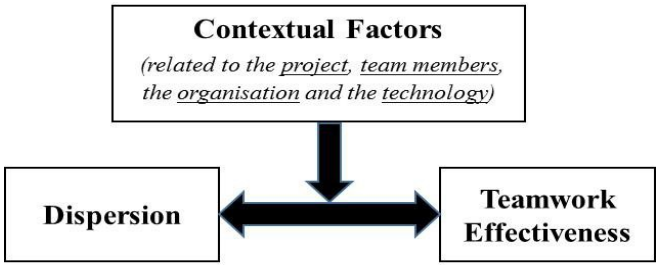

Figure 3-1. Conceptual framework of the research

3.4.1 Description of measures for team dispersion

From all the dispersion measures discussed in chapter 2, certain measures are validated with real-life projects but not with a sufficient number of real-life projects. To answer the research objectives and with taking into account the research limits; seven measures are selected. A summary of all dispersion measures used in this research is provided in Table 3.1.

Table 3.1 Summary of all dispersion measures[1]

Measures	Authors	Definition
1. Spatial index (SI)	O'Leary and Cummings (2007)	Where N* is total number of project team members; N_i is number of project team members of site i; N_j is number of project team members of site j; and D_{ij} is the distance between site i and site j in kilometers
2.Temporal index (TI)	O'Leary and Cummings (2007)	Where N is total number of project team members; N_i is number of project team members of site i; N_j is number of project team members of site j; and TZ_{ij} is the number of time zones between site i and site j
3. Number of sites (NI)	O'Leary and Cummings (2007)	NI= Number of different team members sites
4. Member index (MI)	Schweitzer and Duxbury (2010)	
5. Travel index (RI)	Schweitzer and Duxbury (2010)	
6. Imbalance index (II)	O'Leary and Cummings (2007)	
7. Categorical index (CI)	Cramton and Webber (2005)	Where N is total number of project team members; If this ratio is greater than 0.3 (30%), the CI=1, otherwise CI=0.

1. Information related to the physical location of team members' various locations and the total number of team members across all sites was solicited according to questions [EQ2] of the questionnaire

In order to clarify how each dispersion measure is measured, an example of one project accomplished with a virtual team is provided in Figure 3-2.

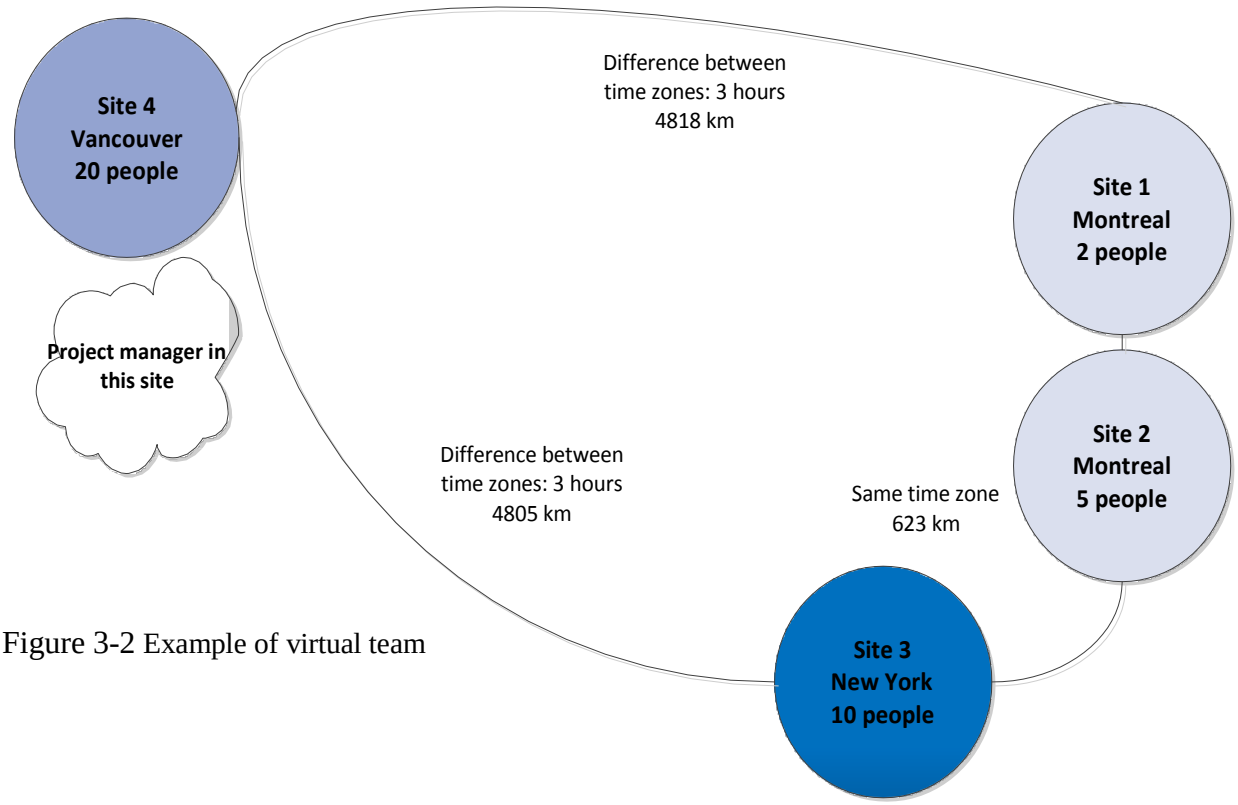

Figure 3-2 Example of virtual team

3.3.1.1 1.1 Spatial Dispersion

Spatial dispersion is an innate characteristic of virtual teams and is the measure most commonly found in the literature (Gibson & Gibbs, 2006; Schweitzer & Duxbury, 2010). According to O'Leary and Cummings (2007), spatial dispersion is considered to be the measurement of geographic distances between sites, weighted by the number of team members in each site. There was one modification made to the original study—the unit of measurement. For the present study, kilometers were used, rather than miles.

Given the example shown in Figure 3-2 and the formula provided in Table 3.1, spatial dispersion was calculated as follows:

3.3.1.2 1.2 Temporal Dispersion

From among the various methods of measuring temporal dispersion, that used by O'Leary and Cummings (2007) was selected.

Given the example shown in Figure 3-2 and the formula provided in Table 3.1, temporal dispersion was calculated as follows:

3.3.1.3 Number of sites

Based on O'Leary and Cummings (2007), the definition of project site would vary according to the study's context. It can describe a floor-, building- or city-level study. In this study, the smallest site unit is a building.

In light of Figure 3-2, the measure of the number of sites was calculated as follows:

3.3.1.4 Member index

According to Schweitzer and Duxbury (2010), the member index reflects the degree of team member dispersion. In contrast to previous assumptions, wherein teams are either co-located or virtual (either 0% or 100%), this measure considers dispersion on a continuum. If we look at the virtual team shown in Figure 3-2, it is clear that, in this case, not all team members are working

in different locations. Given the example of virtual team provided in Figure 3-2, it is clear that in this case, not all the team members are working in different locations. For example there are 10 people who work together in site 1 in Montreal. Therefore, this team is not wholly dispersed. However, since there are people in 4 different sites, this project cannot be considered as 0% dispersed. As such, the concept of considering dispersion on a continuum, with wholly dispersed at one extreme and wholly co-located at the other, is useful.

According to the example presented in Figure 3-2 and Table 3.1, the member index is calculated as follows:

—

%

3.3.1.5 1.5 Travel index

Schweitzer and Duxbury (2010) proposed a new dimension, travel time between sites, as the indicator of geographic distance between the team members. The greater the geographic distance, the fewer face-to-face meetings can be organized. From this standpoint, they concluded that a travel index would be a good measure of the tendency of a team to work virtually versus proximately. This makes sense, considering that the closer team members are to each other, the greater the possibility of choosing between working virtually and co-locating. However, when the geographic distance is significant, working in virtual teams is less and less a choice than a necessity.

For their travel index calculations, Schweitzer and Duxbury (2010) considered an initial hypothetical meeting point. This location was the one that required the least travel time for all members. All scores were then assigned, as shown in Table 3.2, based on this hypothetical meeting point. The total travel index was calculated as the sum of the scores of each project team member.

For the purposes of the current study, the hypothetical meeting point is the project manager’s work site. This reflects the fact that the members of a project team generally hold their face-to-face meetings at the project manager’s site.

Following this, the number of kilometers between the project manager's site and those of other project members was calculated and the travel index was then determined according to Schweitzer and Duxbury's scale (see Table 3.2).

Table 3.2 Distance scores for measuring travel index (adapted from Schweitzer, and Duxbury (2010)

Travel distances	Score
Same city (1/4 day- walk, car, public transit)	0.25
Different cities- same region (1/2 day-car, train)	0.50
Different regions (1.5 days- car, train, airplane)	1.50
Same continent (2 days- airplane)	2.00
Different continents- same hemisphere (2 days- airplane)	3.00
Different hemispheres (3 or 4 days- airplane)	5.00

In the previous example (Fig. 3-2), where the project manager was located in Vancouver, the travel index for the virtual project team was calculated as follows:

3.3.1.6 Imbalance index

Besides the number of sites, an imbalance index proposed by O'Leary and Cummings (2007) was the second index chosen. This measure considers the degree of unevenness of project team members' dispersion across all project sites. This imbalance is germane, since it can account for majority influence and conflict in the project (Cataldo& Nambiar, 2012). Sites with a minority of members can feel "out of the loop" (O'Leary and Cummings (2007). This requires proactive measures to handle communication problems. Using the formula provided in Table 3.1, the imbalance index for the virtual team presented in Figure 3-2 would be calculated as follows:

3.3.1.7 Categorical index

Cramton and Webber (2005) proposed a simplified measure of geographic dispersion, assessing it by defining a dichotomy that assigned a value of 0 if all team members were co-located and 1 if at least 30% of project team members were working in one or more separate offices. Any value falling between 0 and 30% was not included in the calculations. That categorical measure is used in the current study, with a slight modification. This study assigned a value of 1 if more than 30% of project team members were at a location other than the project manager's site. Otherwise, 0 was assigned. This adapted measure makes it possible to distinguish the member density at the project manager's site. If more than 30% of project team members are at a different site than the project manager's site, the categorical index value is 1. In the calculations for the categorical index, the ratio for the first category was calculated. If it was greater than 30%, its index value was 1, otherwise it was 0.

According to Table 3.1 and the example provided in Figure 3-2, categorical index is calculated as the following:

Since the categorical ratio was greater than 0.30, the categorical index value assigned was 1.

3.4.2 Description of measures for contextual factors

In this section, certain project-based and organizational contextual factors that influence teamwork effectiveness are introduced. Being aware of the relationship of these contextual factors with teamwork effectiveness, makes it possible to compare the dispersion measures. The contextual factors considered as control variables are classified in four main categories; nature of the project, project team members, organization and ICT. The summary of these contextual factors are presented in Table 3.3.

Table 3.3 Contextual factors

Category	Contextual factors
Characteristics related to nature of the project	Project team size Project manager experience and managerial skills Similarity of work methods
Characteristics related to project team members	Prior common experience of project team members
Characteristics related to organization	Organizational support Face to face meetings
Characteristics related to ICT	Technological support Virtual meetings

3.3.2.1 Project team size

Regarding the importance of project team size on teamwork effectiveness (Espinosa et al., 2007; Hoegl, 2005), in the current study, project team size is considered to a contextual factor influencing teamwork effectiveness. The database included a question on the number of project members per site (Question [EQ2]). Team size is the total number of project members across all sites.

3.3.2.2 Project manager experience and managerial skills, similarity of work methods and organizational support

The project manager experience and managerial skills measure, recommended by Hoegl and Proserpio (2004), was used by Bourgault and Drouin (2009) in their study of decision making in virtual teams. The current study also considers the impact of project manager experience and managerial skills on the connection between dispersion measures and teamwork effectiveness.

Similarity of work methods has been studied by Chudoba et al. (2005), Lu et al. (2006) and many other authors. In their works, they introduced the concept of discontinuities, or changes to expected conditions. They created this measure to stress the importance of the varying opinions that different team members hold on how a certain job should be done. In their view, this issue arises due to team members' changing, different ways of tracking team members' work and working with people who use different collaboration technologies and tools.

The present study uses a slightly adapted version of their measure, considering similarity of work methods rather than differences in work methods. This decision facilitated the interpretation of the results.

Organizational support for virtual teams includes the training and tools and methods provided by the organization. Training processes have proven to be vital to teamwork success, along with the extent to which the organization provides its employees with tools and procedures that facilitate work in virtual teams. In response to calls for research on training for virtual teams by authors like Hertel et al. (2005), this factor was studied.

Project manager experience, managerial skills, similarity of work methods and organizational support were measured using perceptual scales (Likert 1-to-7 scales) where "1" would represent an absolute disagreement with a statement, and "7" and absolute agreement. This information was extracted from the database. Then, principal-component analysis accompanied by a varimax rotation was performed on these items. This analysis captured 65.83% of the variance. Table 3.4 clearly shows the three blocks of results obtained. This solution was chosen as it compared well to those in similar studies.

With a Cronbach's alpha score of 0.738 for project manager experience and managerial skills, 0.843 for similarity of work methods and 0.603 for organizational support, these measures were confirmed as representative of project manager experience and managerial skills. The Chronbach's alpha score of 0.6 was deemed acceptable for exploratory research in the field of management (Hair Jr, Anderson, & Tatham, 1986).

Similarity of work methods represents 31.99% of the variance effects of dispersion. Project manager experience and managerial skills represents 19.66% and organizational support, only 14.2% of the variance. To ensure that the method component factor analysis is applicable to our study, the covariance of the values was determined using the Kaiser-Meyer-Olkin (KMO), measure of sampling adequacy. The closer this value is to 1, more underlying dimensions there are. Similarity of work methods, project manager experience and managerial skills and organizational support showed a KMO value of 0.764 which is acceptable. The minimum KMO value was set at 0.6. Principal component analysis (PCA) details of these measurements are summarized in Table 3.4.

Table 3.4 Principal component analysis of certain contextual factors (con't)

Items in the questionnaire	Description of items in database	Similarity of work methods	Project manager experience, skills	Organizational support
		Factor 1	Factor 2	Factor 3
GA_3	Project manager had necessary authority to manage this project		0.751	
GA_4	Project manager had experience in management of virtual teams		0.748	
GA_5	Project manager assumed his leadership during the project		0.872	
EQ10c_rev	[illegible]	[illegible]		

Table 3.5 Principal component analysis of certain contextual factors (con't and end)

EQ 10d_rev	In the team, technical skills related to tasks are similar	0.790		
EQ 10f_rev	[illegible]	[illegible]		
EQ 10g_rev	[illegible]	[illegible]		
EQ 10h_rev	[illegible]	[illegible]		
EQ 10i_rev	In the team, the way the conflicts are managed	0.749		
GB_11	My organization have provided training adapted to virtual teams			0.803
GB _12	My organization have provided Tools and methods adapted to virtual teams			0.830
% Variance		31.991	19.655	14.207
Cumulative variance		31.991	51.646	65.853
Cronbach's Alpha		0.843	0.738	0.603

K-M-O = 0.764

3.3.2.3 Face-to-face and virtual meetings

Data on face-to-face and virtual meetings were extracted from the questions EQ12 and EQ13 of the database. The respondents were asked for the number of monthly face-to-face and virtual meetings. Then, the number of meetings was normalized on the basis of the total duration of project. This made the comparison between the projects possible.

3.3.2.4 Technological support and organizational support

The research shows that technology has provided many tools that support the work of virtual teams, including those for organizing virtual meetings and videoconferencing (Tannenbaum et al., 2012). To analyze the impact of virtual meetings on the connection between dispersion measures and teamwork effectiveness, data were extracted from database on a Likert scale of 1-to-7 ranging from less equipped to much more equipped. The question was "In comparison to other teams that you have already worked with, to what extent was this project team equipped with collaboration tools."

Organizational support was assessed based on the database, which queried employee training and tools and methods adapted to virtual teams. This information is provided on the basis of Likert scale of 1 to 7 from absolutely disagreement to absolutely agreement to the questions (GB11 and GB12). The purpose of these items was to provide data for an analysis of the impact of the organization's degree of support on the connection between dispersion measures and teamwork effectiveness.

3.3.2.5 Prior common experience of project team members

Team familiarity, or team members' shared prior work experience, is a concept that has been studied by many authors (Espinosa et al., 2007; Huckman et al., 2009). Prior common experience of project members was evaluated based on responses to "The majority of members have already worked together." In this question (EQ11_j), Participants were asked to rate the truth of this statement on a Likert scale of 1 to 7 from absolutely disagree to absolutely agree.

3.4.3 Description of measures for teamwork effectiveness

Dispersion measures were assessed with a variety of outputs by different authors. In their model, Hoegl and Proserpio (2004) considered the connection between team members' proximity and work quality within a framework that included communication, coordination, balance of member contributions, mutual support, effort, and cohesion. Chudoba et al. (2005) analyzed the relation of three dimensions of virtual dispersion—team dispersion, workplace mobility and variety of work methods—to team performance. In a similar study, Lu et al. (2006) studied the impact of a

variety of work methods—communication, coordination, trust and work outcomes—on different aspects of team performance. Gibson and Gibbs (2006) tested the effects of aspects of team virtual dispersion including geographic dispersion, electronic dependence, dynamic structure and national diversity, on innovation. Schweitzer and Duxbury (2010) used three dimensions—proportion of work time spent working virtually, proportion of member virtuality and degree of separation—and evaluated them according to their relation to virtual team effectiveness. These findings justified the use of co-variants in two sets of variables to evaluate the dispersion measures. To examine the potential of the selected measures, teamwork effectiveness was chosen as the output variable.

The literature review showed teamwork effectiveness was measured by member satisfaction, quality of decisions and achievement of the traditional project indicators of time, budget and quality (Bourgault & Drouin, 2009).

The items provided to measure teamwork effectiveness have already been considered by many authors (Hoegl & Proserpio, 2004; Schweitzer & Duxbury, 2010). This study measured teamwork effectiveness according to Hoegl and Proserpio (2004) member satisfaction criteria. Based on their study, coordination, communication, balance of contributions, mutual support and cohesion were the items considered in measuring teamwork effectiveness. To measure teamwork effectiveness, questions regarding the satisfaction of the tasks are extracted from database with 1 to 7 Likert scale ranging from not satisfied to very satisfied. Then, a principal component analysis was performed. Factor analysis captured 65.99% of the variance with a single factor. The sampling adequacy (KMO) measurement was 0.913 which totally confirms the use of principal component analysis. Cronbach's alpha was 0.935, enough to establish the reliability of these factors for measuring teamwork effectiveness. The details are shown in Table 3.5.

Table 3.6 Principal component analysis of teamwork effectiveness

Items	Description	Monofactor
FB_14	How much you are satisfied from fixing the common objectives in virtual team	0.785
FB_15	How much you are satisfied from planning and organizing the tasks to be realized	0.851
FB_16	How much you are satisfied from organization of work meetings with virtual team members	0.732
FB_17	How much you are satisfied from distribution of the necessary information to all concerned members without considering their location	0.832
FB_18	How much you are satisfied from accomplish the complex tasks (engineering, planning,…) with the help of ICT	0.810
FB_19	How much you are satisfied from exchanging the ideas, solve the problems and make decisions in virtual teams	0.846
FB_20	How much you are satisfied from solving the personnel conflicts	0.721
FB_21	How much you are satisfied from monitoring and evaluation of the project	0.871
FB_22	How much you are satisfied from building a favorable work environment	0.850
% Variance		65.991
Cumulative variance%		65.991
Cronbach's Alpha		0.935

K-M-O = 0.913

3.5 Data Analysis

The statistical methods for presenting the results included a two-tailed Pearson and partial correlations. The two-tailed Pearson correlation was chosen to provide a general analysis of

correlations because the current study is exploratory and consequently the objective is to determine whether the correlations exist or not. Correlation analysis began with a two-tailed Pearson correlation between dispersion measures and teamwork effectiveness. The next step was to consider partial correlations to analyze the relation between dispersion measures and teamwork effectiveness when controlled by other dispersion measures. Statistically speaking, controlling by a variable means eliminating the effect of that specific variable on the relationship. This objective is done with keeping the specific variable as constant during analysis. Following this, the relation was analyzed using one contextual factor as a control variable. Finally, the relation was studied when controlled by both the dispersion measures and one contextual factor

CHAPITRE 4 PRESENTATION OF THE RESULTS

Since the main objective of research is comparing various indices proposed in the literature when applied to a sample of real projects, and determining the index that best fits, the purpose of this chapter is to use a systematic approach to introduce and analyze the relation between dispersion measures and teamwork effectiveness, considering certain project-based and organizational contextual factors. The contextual factors were introduced to check whether various attributes of the project and the organization had an impact on the relation of dispersion measures to teamwork effectiveness. Eliminating the effect of certain contextual factors, if the relation between dispersion measures and teamwork effectiveness was altered by a particular contextual factor, it was considered to have significant validity.

The chapter begins with a descriptive analysis (Section 4.1) that includes a presentation of the sample, dispersion measures, contextual factors and teamwork effectiveness. In Sections 4.2 and 4.3, all possible relations between the dispersion measures, contextual factors and teamwork effectiveness are studied. In Section 4.2, the focus is on simple dispersion measures while in Section 4.3, the combination of two or three measures is considered to create the combined measures. Taking combined measures into account helps determine whether or not the measures have a collective impact on teamwork effectiveness.

As mentioned in previous chapter, the dispersion measures studied here are the spatial index, temporal index, number of sites, member index, travel index, imbalance index and the categorical index. The contextual factors are considered in four distinct categories. The first category looks at contextual factors related to the nature of the project. The second considers contextual factors associated with project team members. The third involves organizational contextual factors and the forth is about ICT.

4.1 Descriptive analysis

In this section, a brief summary of the sample description is presented in Section 4.1.1., followed by a descriptive analysis of the dispersion measures, contextual factors and teamwork

effectiveness in Section 4.1.2. This provides a good understanding of the sample and the characteristics of each variable.

4.1.1 Sample presentation

A description of the sample is important for a good understanding of the results and analysis. The current data base included data collected from 149 project members with at least one year of experience working with virtual teams. The central tendency (mean) and dispersion (standard deviation) were calculated for all the variables contributing to the sample. Variable normality, including asymmetry and kurtosis coefficients was verified. Both spatial dispersion and travel index variables showed skewed distributions, so they were log-transformed. Additionally, inverse function was used to transform temporal dispersion data.

The projects studied are for this paper varied considerably in different ways. The average project duration was 19.3 months, with a minimum of 2 weeks and a maximum of 5 years. The average budget was $54,534,110. The number of project team members ranged from 2 to 460. The percentage of project managers who had a Project Management Professional (PMP) certificate was 28.2%. Also the average prior project management experience was 8.4 years. The organizations in which the projects were accomplished had between 2 and 500,000 employees and worked in different sectors, including public works (electricity, gas and water), construction, manufacturing, finance and insurance, professional, scientific and technical services, healthcare and social assistance and public administration. One third of the organizations in the database were involved in professional, scientific and technical services and 63.76% of these project teams worked virtually from at least two sites. Virtual team locations spanned 5 continents and represented a total of 26 countries and 138 cities. The sample characteristics are shown in Table 4.1.

Table 4.1 Sample Presentation

Descriptive elements	Minimum	Maximum	Average	Standard deviation
Respondent profile				
Experience in the sector of activity (years)	1	36	12.13	7.48
Project management experience (years)	0	32	8.38	6.21
Characteristics of projects				
Project duration (months)	0.50	60	19.34	13.77
Project budget (M CDN$)	0.01	2000	54.53	269.74
Number of team members related to the project	2	460	28.31	61.85
Characteristics of organization				
Number of employees	2	500000	10260	48050
Gross annual turnover (M CDN$)	0.115	400000	3445.60	32831.38

4.1.2 Statistical data of dispersion measures and contextual factors

To describe the characteristics of the sample, the mean, minimum, maximum and standard deviations of all dispersion measures, contextual factors and teamwork effectiveness measures are provided in Table 4.2 and Table 4.3.

To eliminate the effect of different units of measurement, the coefficient of variation was calculated so geographic dispersion measures could be compared. The coefficient of variation of a measure is found by dividing the standard deviation by the mean, thus eliminating the unit of measurement.

According to Table 4.2, in all cases, deviations from the mean of dispersion measures were considerable. Of these, travel index, temporal dispersion and spatial dispersion were most variable. Travel index has a high coefficient of variation. Project team members' need to travel

to reach the project manager's site showed considerable variability (303.55%). The data for measuring temporal dispersion and spatial dispersion measure varied as well, reflecting considerable variation between projects in terms of both the geographic distance between them and time zones spanned by their project sites. As Table 4.3 shows, all contextual factors are variable. Among them, face-to-face and virtual meetings vary considerably (254.37% and 136.01%, respectively, are the coefficients of variation). Prior common experience of project team members was also found to be variable in different projects. In other words, the sample benefits from a vast range of projects which gives the research the validity.

Table 4.2 Descriptive statistics of dispersion measures[1]

Statistics	Spatial index (SI)	Temporal index (TI)	Number of sites (NI)	Member index (MI)	Travel index (RI)	Imbalance index (II)	Categorical index (CI)
Means	1692.36	0.92	3.72	32.37	24.16	0.16	0.89
Minimum	0 [4]	0	2	0.65	0.25	0	0
Maximum	8541.27	8.57	8.00	100.00	791.00	0.54	1.00
σ^2	2013.92	1.70	1.82	23.66	73.33	0.11	0.32
CV[3]	119.00	183.66	48.87	73.08	303.55	65.76	35.94

1. For the description of dispersion measures in the research see Section 3.3.1

2. σ: Standard deviation

3. CV: Coefficient of variation= standard deviation/means

4. If there are two project sites in the same city, the spatial index is calculated as 0.

Table 4.3 Descriptive statistics of contextual factors and teamwork effectiveness[1]

Statistics	Teamwork effectiveness	Experience and skills	Similarity of work	Prior common experience	Support-ORG	Support-TECH	Face-to-face meetings	Virtual meetings
Means	5.06	5.41	3.91	3.49	3.54	4.35	0.79	3.93
Minimum	1	2	1	1	1	1	0	0
Maximum	7	7	7	7	7	7	14	30
σ^2	1.164	1.24	1.35	2.16	1.59	1.28	2.02	5.34
CV[3]	23.02	22.84	34.62	61.85	45.04	29.39	254.37	136.01

1. For the description of contextual factors and teamwork effectiveness in the research see Sections 3.3.2. and 3.3.3.

2. σ: Standard deviation

3. CV: Coefficient of variation= standard deviation/means

4.2 Correlations of simple dispersion measures, contextual factors and teamwork effectiveness

In this section, the connections between simple dispersion measures, contextual factors and teamwork effectiveness are systematically studied. First, all simple correlations between dispersion measures, contextual factors and teamwork effectiveness were examined using two-tailed probability and Pearson correlation tests in Section 4.2.1. Then the relationship of dispersion and teamwork effectiveness was controlled by all other dispersion measures, providing the results given in Section 4.2.2. This relationship was then controlled by one contextual factor in Section 4.2.3. Finally, in Section 4.2.4, the relation of dispersion measures to teamwork effectiveness is analyzed while controlled, not just by all dispersion measures, but also by one contextual factor.

4.2.1 Correlation of dispersion measures, contextual factors and teamwork effectiveness

The principle correlation matrix is composed of three main blocks: the dispersion measures, contextual factors and teamwork effectiveness. In this matrix, the relation of each block, meaning the relation of each dispersion measure with other dispersion measures, the relation of each contextual factor with other contextual factors, and the relation of each dispersion measure and contextual factor with teamwork effectiveness, are presented. Besides the interrelationships of each block, the connections of each dispersion measure with each contextual factors are also introduced. The correlation matrix which leads to the global vision of all simple measures of dispersion, contextual factors and teamwork effectiveness are shown in Table 3.4.

Table 4.3 Matrix of correlations between variables[1]

No.	Indices	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Spatial index	1															
2	Temporal index	-0.669****	1														
3	Site index	*0.194***	-0.124	1													
4	Member index	0.113	0.007	0.590****	1												
5	Travel index	0.744****	-0.613****	0.109	-0.525****	1											
6	Imbalance index	0.093	-.134	-0.298****	-0.375****	0.077	1										
7	Categorical index	0.153*	0.036	0.379****	0.186**	0.152*	-0.663****	1									
8	Team size[2]	NA	NA	NA	NA	NA	NA	NA	1								
9	Experience and skills	0.119	-0.138	0.021	0.223**	0.230***	-0.014	-0.114	-0.190**	1							
10	Similarity of work	0.207**	-0.183**	0.060	0.225**	0.295****	0.007	-0.100	-0.157*	0.264**	1						
11	Prior common experience	0.135	-0.100	0.065	0.090	0.168*	0.018	-0.173**	-0.066	0.069	0.182**	1					
12	Support-ORG	0.082	-0.125	-0.009	0.135	0.079	-0.021	-0.035	-0.085	0.323****	0.198**	0.128	1				
13	Support-TECH	0.077	-0.090	-0.094	0.024	0.042	0.165*	-0.212**	0.023	0.132	0.075	0.068	0.250***	1			
14	Face-to-face meetings	-0.148	0.043	-0.255***	-.095	-0.134	0.108	-0.082	-0.134	-0.050	-0.186**	-0.101	-0.015	0.038	1		
15	Virtual meetings	0.254***	-0.145	0.003	0.002	0.206**	-0.028	0.055	0.041	0.165*	-0.053	-0.109	0.142	0.190**	0.065	1	
16	Teamwork effectiveness	0.127	-0.153*	0.013	0.220**	0.187**	0.031	-0.104	-0.215**	0.652****	0.263**	-0.016	0.458****	0.203**	0.090	0.073	1

1. Two-tailed test of Pearson correlation with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

2. The correlation between dispersion measures and team size is not applicable because they are already standardized by team size.

First of all, the relation of each dispersion measure is discussed with other dispersion measures. Spatial dispersion (distance) is correlated to temporal dispersion (time zone) to a great extent (0.66): the more geographically distant team members are, the greater the number of time zones; the more team members' time zones differ, the greater the chance that they are geographically dispersed. Note that the negative sign of correlation occurs because the inverse function is applied to temporal dispersion. The strong correlation of spatial and temporal dispersion corresponds exactly to what is expected. The other considerable correlation (0.74) was observed between travel index and spatial dispersion in our sample: the further team members travelled to the project manager's site for meetings, the greater their geographic dispersion; the more geographically dispersed, the more travel for face-to-face meetings. This correlation is due to the formulas to calculate each dispersion measure. As already stated, travel dispersion is defined by sum of the scores form the manager site. The criteria to define these scores, is travel distance that has the same basis of calculation of spatial dispersion. For example, if there is a project with two sites in Montreal and Vancouver, being situated in different provinces; the score to calculate travel index increases. This increase in travel index is related to geographic distance between the sites.

Spatial dispersion is less correlated to two dispersion measures; number of sites and categorical index that is consistent with the expectations. Spatial dispersion correlated to the number of sites: the more project sites there are, the more geographically dispersed the team members; the greater the geographic distance, the greater the number of sites. However, the concepts of geographic distance and number of sites are not that related. In a project done in Montreal and Vancouver, it is probable to have one site in each city or to have 5 sites in each city. With the same spatial dispersion, the number of sites are varied The categorical index, a binary measure effective when more than 30% of the project team is outside the project manager's site, was also correlated to geographic distance and showed: the more people work in locations other than the project manager's, the more they are geographically dispersed; the more people work outside the project manager's site, the higher the degree of spatial dispersion. It is possible to have most of the project members outside of the project manager's site which is in Vancouver, whereas the project sites are located really near each other in the cities nearby. So, having more people out of project sites is not strongly related to spatial dispersion.

Temporal dispersion besides being correlated to spatial dispersion, is correlated to the travel index to great extent (0.61): the more team members there are in different time zones, the more they travel to meet other project members; the greater the number of travel hours between sites, the greater the number of time zones. As temporal index is correlated to spatial index and spatial index is correlated to travel index; temporal index is also correlated to travel index. Travel index is based on the idea of geographic distance and as already mentioned geographic distance is correlated to temporal dispersion.

The number of sites was found to strongly be correlated to member index: the greater the number of sites; the more the members were dispersed; the greater the member dispersion, the greater the number of sites. Since the member index is defined as the number of sites per project team member, it was expected to correlate to the number of sites.

The number of sites correlated to two other dispersion measures but with less degree of correlation; imbalance index and categorical index. The number of sites correlates to the imbalance index: the more team members in different sites, the less imbalanced the project team; the more the project team is unbalanced, the fewer the sites. Therefore, with an increase in the number of sites, greater balance in the team is expected. However, it is not always true. Two projects are considered, the first one with two sites and 5 people in each site and the second one with 3 sites and with 4, 4, 2 member arrangement in each site. The first project with less project members is more balanced. The number of sites is also correlated to the categorical index: the greater the number of sites, the more team members are located outside of the project manager's site; the more members outside of the project manager's site, the greater the number of different sites. It is probable to have a project with two sites. The most of project members are located out of project manager's site. Whereas, the other project has three sites and most of the project team members are situated in project manager's site. The relation of number of sites and being situated in project manager's site is not strong then.

The member index is strongly correlated to the travel index: the greater the number of sites per project team member, the less travel to reach each other; the greater the necessity of travel between sites, the lower the number of sites per project member. This result is counterintuitive. As there are more sites for each project team member, it is expected to have more travels between

sites. The member index is also correlated with the imbalance index: the greater the proportion of number of sites per member, the less the imbalance; the less imbalanced the members' dispersion, the greater the proportion of member dispersion. The member index and categorical index are also correlated: The greater the member dispersion, the more team members there are outside of the project manager's site; the more people outside the project manager's site, the greater the member dispersion. This result is not expected. More the site per project member is, less balanced arrangement of project team members is expected.

The travel index was also found to be correlated with the categorical index, but to a small degree: The more team members travel to reach the project manager's site, the greater the number of members situated outside the project manager's site; the greater the number of team members outside the project manager's site, the more they need to travel to reach it. It is normal that with 90% of project team members outside of project manager's site, the number of travels between the sites is greater.

The imbalance index is strongly correlated to the categorical index: the greater the imbalance of team dispersion, the fewer members there are outside the project manager's site; the more members outside the project manager's site, the greater the balance of the team. This result consists with what is expected.

Afterwards, the relation between different dimensions of dispersion and contextual factors are presented. A correlation between similarity of work methods and spatial dispersion was found: the more team members share similar work patterns and equipment, the more they are geographically dispersed; the more team members are geographically dispersed, the more they share work patterns. However, it looks totally counterintuitive at first, this issue could be related to maturity of organizations which benefit from virtual teams. In order to make use of the resources in an efficient way and to change the challenges of collaboration into opportunities, they have similar work methods. A correlation between virtual meetings and spatial dispersion was also found: the greater the dispersion of the project team, the more the virtual meetings; the more virtual meetings there are, the greater the team members' geographical dispersion. It is logic to have more virtual meeting when geographic dispersion is greater.

Another correlation was found to exist between the number of sites and the number of face-to-face meetings: the more face-to-face meetings held during the project, the fewer the sites; the more project sites, the fewer face-to-face meeting are held. The cause would be the organizations with the greater number of sites have tendency to use virtual meetings rather than face-t-face meetings.

The member index and project manager experience and managerial skills are correlated: the more virtual the team, the greater the project manager's skill; the greater the project manager's expertise, the more the members are dispersed. The reason might be due to the challenges of working in virtual teams. If the work is going to be done in a virtual manner, the organizations tend to select an experienced project manager.

Finally, the member index was correlated to similarity of work practices: the more the member dispersion in a project team, the more similar the work patterns in different sites; the more the team had similar work methods, the greater the member dispersion.

The second block discusses the relation of dispersion measures and contextual factors. There is not a big difference between these correlations. The travel index is correlated to project manager experience and managerial skills as well: the more team members travel to reach the project manager's site, the greater the project manager's experience; the greater the project manager's experience, the more travel to the project manager's site. The travel index is also correlated to similarity of work practices: the more team members travel to reach the project manager's site, the more similar the work patterns; the more similar the work patterns, the more travel required to reach the project manager's site. Travel index is also correlated to the project team's prior common work experience: the more team members travel to other project sites, the more prior experience of working together; the more prior common experience, the more members travel to the project manager's site. The travel index is correlated with virtual meetings: the greater the travel score, the more virtual meetings; the more team members hold virtual meetings, the greater the travel score.

The imbalance index is correlated to the technological support provided by the company: the greater the team imbalance, the more technological support offered by the company; the greater the technological support, the more the imbalance.

The categorical index was found to be correlated to the prior common experience of project team members: the more team members outside the project manager's site, the less prior common experience in the team; the more prior common experience, the fewer the members outside the project manager's site. There is also a correlation between the categorical index and technological support: the greater the number of project members outside the project manager's site, the less technological support provided by the organization; the more technological support provided by the company, the fewer team members outside the project manager's site.

The third block discusses the stronger correlations of contextual factors together. The strongest correlation is between project manager experience and managerial skills and organizational support: the greater the project manager's skill, the more support provided by the organization; the greater the amount of support provided by the company, the greater the competence of the project manager. Experienced project managers have more tendencies to work in mature organizations and these mature organizations provide more organizational support.

Project manager experience and managerial skills proved to be correlated with team size (number of project team members): the greater project manager's expertise, the smaller the project; the larger the project, the less experience of the manager. This observation is not as expected. Regularly, experienced project managers are found in broader projects with more people.

Project manager experience and managerial skills correlates to similarity of work practices: the greater the project manager's expertise, the more similar the work patterns in all sites; the more similar the work patterns, the greater the skill of the project manager.

Project manager experience and managerial skills is also correlated with virtual meetings: the greater the project manager's competence, the more virtual meetings are held; the more virtual meetings, the greater the project manager's expertise. Project manager experience and managerial skills is correlated with teamwork effectiveness: the greater the project manager's expertise, the greater the team's effectiveness; the greater the team's effectiveness, the greater the project manager's skill.

Similarity of work practices also proved to be correlated with team size: the more similar the work patterns, the smaller the project; the bigger the project, the less similar the work patterns.

Teamwork effectiveness was found to be correlated to team size: the bigger the project, the less effective the teamwork; the more effective the teamwork, the smaller the project. Similarity of work practices is correlated with prior common work experience. The more similar the work patterns, the greater the prior common experience; the greater the level of prior common experience, the more similar the work patterns. Similarity of work practices is correlated with organizational support (such as training courses on collaborating from different sites) as well: the more similar the work patterns, the greater the organizational support; the more organizational support provided, the more similar the work patterns across the sites. Similarity of work practices is correlated with face-to-face meetings: the more similar the work patterns, the fewer face-to-face meetings; the more face-to-face meetings, the less the similarity in work patterns. The similarity of work practices is also correlated with teamwork effectiveness: the more similar the work patterns, the more effective the teamwork; the more effective the teamwork, the more work practices resemble each other.

Organizational support is correlated to technological support: the more organizational support is provided, the more technological support is also provided; the more technological support provided, the greater the organizational support. Organizational support is also correlated with teamwork effectiveness: the more organizational support provided, the more effective the teamwork; the more effective the teamwork, the more organizational support provided.

Technological support is correlated with virtual meetings: the more technological support provided by the company, the more virtual meetings are held; the more virtual meetings held, the more technological support provided. Technological support is also correlated with teamwork effectiveness: the more technological support provided, the more effective the teamwork; the more effective the teamwork, the more technological support provided.

Of all dispersion measures, site index, member index and travel index are correlated with teamwork effectiveness. The relationship between the number of time zones (temporal index) and teamwork effectiveness is significant: the more effective the work, the greater the number of time zones; the more time zones, the more the efficient the teamwork. The member index was also found to correlate with teamwork effectiveness: the higher the virtual member proportion, the greater the effectiveness of teamwork; the more effective the teamwork, the greater the member

dispersion in the project team. The travel index is also correlated with teamwork effectiveness: the more team members must travel to reach the project manager's site, the more effective the teamwork; the more effective the teamwork, the more travel to the project manager's site.

Member index is the most correlated dispersion measure with teamwork effectiveness. It might be because of the consideration of the number of sites and the number of project team members at the same time.

Among all the measures of dispersion, the member index explains 4.84% (0.22^2) of the variation in the relationship between all dispersion measures and teamwork effectiveness. This number (0.22) is the correlation of member index and teamwork effectiveness. In the same way, the travel and temporal indices explain 3.5% (0.187^2) and 2.34% (0.153^2), respectively, of the variation in the relationship between dispersion measures and teamwork effectiveness.

Among the contextual factors, project manager experience and managerial skills alone explains 42.51% (0.652^2) of the relationship between dispersion measures and teamwork effectiveness. This contextual factor is a vital consideration for the management of virtual teams.

Organizational support captures 20.98% (0.458^2) of the variance between dispersion measures and teamwork effectiveness.

Team size, similarity of work methods and technological support affect the variation between dispersion measures and teamwork effectiveness as well but to a lesser degree, at 4.62 % (0.215^2), 6.91% (0.263^2), and 4.12% (0.203^2), respectively.

According to principal matrix of correlations, some correlations are counterintuitive. The travel index is not correlated with the number of sites.

4.2.2 Correlation of each dispersion measure and teamwork effectiveness controlled by all other dispersion measures

The objective of this section is to show the influence of each dispersion measure on teamwork effectiveness when the effect of other measures is eliminated. The relation of each dispersion measure to teamwork effectiveness is controlled by all other dispersion measures to study their importance. As already mentioned, the research objective is to compare dispersion measures. In

order to define the pure relationship of each dispersion measure with teamwork effectiveness, the effect of other dispersion measures are eliminated. For example spatial dispersion and temporal dispersion are correlated to great extent. This correlation may interfere the relation of each of them with teamwork effectiveness. In order to have the exact relation of spatial dispersion with teamwork effectiveness, the relation should be controlled by temporal dispersion.

Table 4.4 Correlation of each dispersion measure and teamwork effectiveness controlled by all other dispersion measures[1]

Measures	Teamwork effectiveness
Spatial index	-0.028
Temporal index	-0.049
Number of sites	-0.018
Member index	0.221**
Travel index	0.116
Imbalance Index	0.020
Categorical index	-0.089

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

Based on Table 4.5, only the relationship between member index and teamwork effectiveness is significant. The member index (number of sites divided by the number of project team members) is the only measure which is related to teamwork effectiveness. In the context of technological projects in the current research, this measure which considers two factors of the number of sites and project team members is observed to be the best fit. However, number of sites is not correlated to teamwork effectiveness. Considering the number of sites is not sufficient to define dispersion. Spatial, temporal, travel, or imbalance indices are not correlated to teamwork effectiveness either. It would be in behalf of the organizations which already set up the mechanisms to handle dispersion when having certain conditions. These certain conditions

include having sites which are geographic distant, extended on different number of time zones or imbalanced arrangement of project team members in sites.

4.2.3 Correlation of dispersion measures and teamwork effectiveness considering the individual contextual factors

Among all the contextual factors introduced in this work, which ones are probable to have impact on the relationship of measures of dispersion and teamwork effectiveness? Contextual factors are considered in the relationship of dispersion measures and teamwork effectiveness in order to study the pure relationship of dispersion measures and teamwork effectiveness. Each project has its own characteristics called contextual factors. To be able to compare the projects at the similar situation, the effect of these factors are eliminated in this part. Table 4.6 is presented to discuss the relation of each dispersion measure with teamwork effectiveness by eliminating the effects of contextual factors.

Table 4.5 Correlation of dispersion measures and teamwork effectiveness considering individual contextual factors[1]

	Teamwork effectiveness						
	Experience and skills	**Similarity of work**	**Prior common Experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index	0.067	0.082	0.133	0.101	0.114	0.138	0.110
Temporal index	-0.085	-0.115	-0.157*	-0.109	-0.138	-0.156*	-0.143
Site index	-0.001	-0.002	0.015	0.019	0.034	0.030	0.013
Member index	0.101	0.171*	0.223**	0.180**	0.220**	0.231**	0.221**
Travel index	0.053	0.126	0.195**	0.170*	0.182**	0.197**	0.174*
Imbalance index	0.053	0.030	0.032	0.046	-0.002	0.022	0.033
Categorical index	-0.042	-0.083	-0.112	-0.099	-0.062	-0.100	-0.110

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

With considering all other dispersion measures as control variables, member index is still the dispersion measure that is correlated with teamwork effectiveness. In Table 4.6 the relationship between the temporal index and teamwork effectiveness is lost when various contextual factors, including project manager experience and managerial skills, similarity of work practices, organizational and technological support and virtual meetings are considered.

The connection between the member index and teamwork effectiveness is also lost when project manager experience and managerial skills are considered. With respect to the travel index, the connection is also lost when project manager experience and managerial skills and similarity of work practices are considered. The relationship between the temporal index and teamwork effectiveness remains significant only with two contextual factors—face-to-face meetings and prior common experience of project team members.

As mentioned in principle correlation matrix in section 4.2.1, temporal index, member index and travel index all three were correlated with teamwork effectiveness. Whereas, in the current section (Table 4.5) the contextual factor “project manager experience and managerial skill” caused the relation to disappear. Since this contextual factor is capable of changing the existing connection between the mentioned dispersion measures and teamwork effectiveness, it can be concluded that project manager experience and managerial skills are shown to be a salient factor in teamwork effectiveness.

4.2.4 Correlation of dispersion measures and teamwork effectiveness controlled by all dispersion measures and individual contextual factor

The concept of controlling by dispersion measures is added to the analysis to control all the factors that interfere in the relation of each dispersion measures and teamwork effectiveness, including other dispersion measures and each contextual factor. The findings resulting from the addition of all dispersion measures and individual contextual factor as control variables are shown in Table 4.7. Note that each contextual factor is treated separately in the relationship of dispersion measures and teamwork effectiveness.

Table 4.6 Correlation of each dispersion measure and teamwork effectiveness controlled by all dispersion measures and a contextual factor[1]

	Teamwork effectiveness						
	Experience and skills	**Similarity of work**	**Prior common experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index	0.005	-0.028	-0.021	-0.038	-0.040	-0.018	0.110
Temporal index	-0.054	-0.051	-0.042	0.000	-0.041	-0.041	-0.143
Site index	-0.017	-0.019	-0.007	0.030	0.004	-0.006	0.013
Member index	0.085	0.170*	0.227**	0.183*	0.205**	0.234**	0.221**
Travel index	-0.002	0.083	0.128	0.144	0.126	0.121	0.174*
Imbalance index	0.058	0.023	0.010	0.033	0.014	0.016	0.024
Categorical index	0.005	-0.065	-0.113	-0.085	-0.069	-0.096	-0.110

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

As already mentioned in Table 4.6 (section 4.2.3), the relationship between the member index and teamwork effectiveness remains significant with all contextual factors except project manager experience and managerial skills. When controlled by project manager experience and managerial skills; the relationship between member index and teamwork effectiveness disappears. This fully confirms the conclusion of Section 4.2.3, which focuses on project manager experience and managerial skills as an essential management tool in a virtual environment.

The travel index and teamwork effectiveness were not significantly correlated when the effect of other dispersion measures was considered (Section 4.2.2). In Table 4.7 the travel index is not shown to be significantly correlated with teamwork effectiveness when controlled by any contextual factor except virtual meetings. Virtual meetings cause this relationship to be

significant, as shown in Table 4.7. The result shows that the importance of virtual meetings to teamwork effectiveness should not be denied in virtual team management.

The temporal index did not emerge as significant to teamwork effectiveness when controlled by any contextual factor.

The concept of adding other dispersion measures as control variables in the relation of member dispersion and teamwork effectiveness didn't make significant difference. In other words, member dispersion is not sensible to other dispersion measures.

4.3 Correlations of combined dispersion measures, contextual factors and teamwork effectiveness

To find the measure of dispersion that best fits our sample, since it was not clear whether it would be a simple dispersion measure or a combination of two or three indices, combined measures were created. These measures were produced as cross products of two and three measures. Considering combined measures provides the possibility to study different dimensions of dispersion measures at the same time. The same procedures of the section 4.2 on simple dispersion measures are done for combined measures here. Each of dispersion measures measure a certain part of the overall dispersion. To have a graphical presentation, the different dispersion measures are presented in Figure 4-1. This graph shows that with the combination of two measures like spatial and temporal dispersion, more of the overall dispersion is covered. The interpretation is that with two dispersion measures, there is the wider chance to study dispersion.

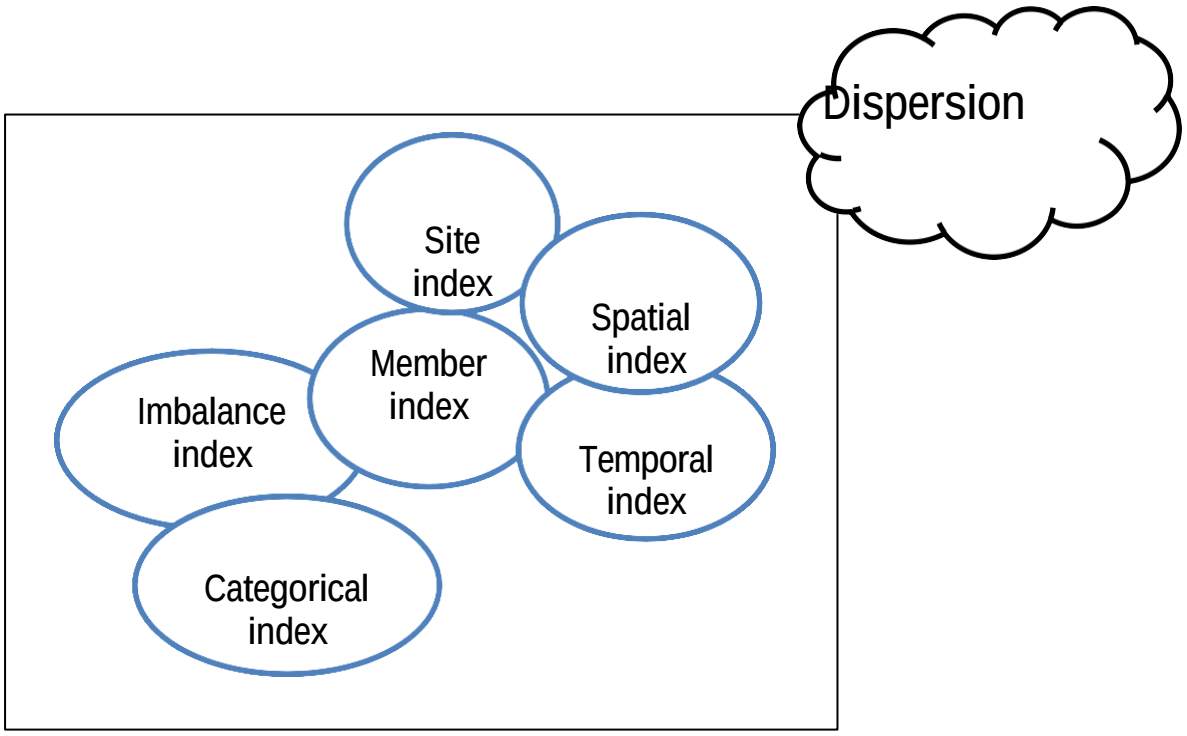

Figure 4-1 Graphical presentation of combined measures

The combined effect of these measures on teamwork effectiveness was first studied with no consideration of contextual factors, then re-examined considering project-based and organizational contextual factors. Studying the combined measures provides the consideration of two or three dimensions of geographic dispersion at the same time.

4.3.1 Correlation of combined dispersion measures and teamwork effectiveness

The relationship between combined measures and teamwork effectiveness is studied. In this level, neither other dispersion measures nor contextual factors are integrated in the analysis. None of the combined measures was shown to be significant in relation to teamwork effectiveness. This issue could be due to the fact that the dispersion measures neutralize the effect of each other as a whole on teamwork effectiveness (see Appendix B).

4.3.2 Correlation of combined dispersion measures and teamwork effectiveness controlled by all measures of dispersion

To follow the same logic as the previous chapter, the relation of combined measures and teamwork effectiveness are studied using all measures of dispersion as control variables. The purpose is to eliminate the effect of the other dispersion measures.

The only measure correlated with teamwork effectiveness is the combined measure of the spatial, temporal and travel indices (STR) when all other measures of dispersion are used as control variables. To clarify, when the cross product of the STR index is derived, and all other dispersion measures are kept controlled, this combined measure and teamwork effectiveness is observed to be correlated, with a -0.154 degree of correlation and a significance level (p-value) of 0.093. The advantage of this measure over the simple measure of dispersion measure that was correlated to teamwork effectiveness is that this combined measure considers the three dimensions of dispersion at the same time.

Note that considering the combination of spatial and temporal (ST), spatial and travel (SR) or temporal and travel (TR) indices does not reveal any significant correlations. A combination of two-by-two of each of these measures cancels the relation of the whole combined measure on teamwork effectiveness. However, when these three measures are considered simultaneously, they show an effect on the relation of this combined measure and teamwork effectiveness. The complete table is provided in Appendix C.

It is also an interesting result that STR was not correlated with teamwork effectiveness without eliminating the effect of other dispersion measures. The correlation of other dispersion measures with this combined measure was the reason why it wasn’t correlated at first.

4.3.3 Correlation of combined dispersion measures and teamwork effectiveness considering the individual contextual factors

To analyze the possible effects of project-based, project members, ICT and organizational contextual factors on the relationship of combined dispersion measures and teamwork effectiveness, related partial correlations were sought. Eliminating the effect of individual

contextual factors make it possible the study of the pure relation of combines dispersion measures and teamwork effectiveness.

The only combined measure that proved to be significant when its relation with teamwork effectiveness was controlled by organizational support was the cross product of spatial dispersion, site index, and travel index.

This underscored the role played by organizational support in the relation of the cross product of spatial dispersion, site index and travel index (SNR) to teamwork effectiveness with a correlation of -0.163 and a significance level of 0.081.

Organizational support is shown to play a considerable role in the relation between spatial dispersion, number of sites and travel index on the one hand and teamwork effectiveness on the other, given that in the beginning spatial dispersion and number of sites weren't considered to be correlated with teamwork effectiveness (see Appendix D).

4.3.4 Correlation of each combined dispersion measure and teamwork effectiveness controlled by all other measures and a contextual factor

In Section 4.3.2, the correlation of the cross product of spatial, temporal and travel indices with all measures of dispersion as the control variables was found to be significant with teamwork effectiveness. To understand the role contextual factors might play in this relationship, statistical procedures were performed.

Two factors, prior common experience of team members and technological support were shown to have an impact on teamwork effectiveness. The only measure significantly correlated to teamwork effectiveness was the cross product of the spatial, temporal and travel indices. The correlation value for technological support is -0.154 and the significance value is 0.095. The correlation value of prior common experience of working together is -0.164 and the significance value is 0.074.

If team members have prior experience of working together, they can manage dispersion more effectively. Similarly, if technological support is provided by the company, it has a remarkable impact on teamwork effectiveness (see Appendix E).

4.4 Summary and remarks

Based on the research findings, the member index was found to be the best single measure of dispersion that fits our sample. The proportion of number of sites to total number of project members across all sites is a good indicator of a project team's level of virtuality in the context of technological projects. The other dispersion measures are not correlated with teamwork effectiveness. The reason could be that the organizations have already designed the mechanisms to handle dispersion in their internal processes.

Searching for a combined measure which considers the multi-dimensional nature of dispersion led to the analysis of two-by-two and three-by-three of the dispersion measures. The cross product of two-by-two dispersion measures were not correlated with teamwork effectiveness. It would be probable that these measures neutralize the effect of each other.

Of all the combined dispersion measures, the combined measure of the STR and SNR are proved to capture dispersion in the best way. These three-dimensional dispersion measures integrate the different concepts of dispersion at the same time. As spatial, temporal and travel index are correlated together to great extent, the combination of three are expected to be correlated with teamwork effectiveness. In the second combined measure of dispersion, simple measures of site and travel index are not correlated, but as a whole the combination of the three including spatial, travel and site indices are correlated to dispersion measures. As a matter of fact, spatial dispersion acts like a connector and as a whole, the integration of three is correlated to teamwork effectiveness.

Virtual meetings, organizational support, and project manager experience and managerial skills are three contextual factors which actively played the role in the relation of dispersion measures and teamwork effectiveness. These contextual factors are of vital importance in the context of technological projects.

CHAPITRE 5 DISCUSSION

In this chapter, the results are compared to those found in the literature and the theoretical and managerial implications of the study are discussed. Following this, the limitations of the study are presented and suggestions for future work are provided.

To recall the main goals of this study:

- Create a database including measures most commonly found in the literature for geographic dispersion.
- Compare a selection of geographical dispersion measures from a conceptual and empirical view.
- Validate the selected measures based on a sample of real-life projects.
- Analyze the potential relationship between selected dispersion measures and teamwork effectiveness considering certain project and organizational contextual factors
- Make recommendations for future team dispersion measures

All the objectives of the thesis have been achieved. The first and second objectives were reached in the Chapter 2 (literature review). The third objective is discussed in the Chapter 3 and 4 of the thesis (research design and presentation of results). The forth objective is analysed in Chapter 4 (presentation of the results). And finally, the last and fifth objective is discussed in this chapter (discussion).

5.1 Summary of Key Findings and Propositions

This study involved a study of geographic dispersion measures. From these measures, certain dispersion measures that were applicable to real-life projects were selected. The simple measures from the literature include the number of sites and spatial, temporal, member, travel, imbalance and categorical indices. Besides these simple measures, combined measures were designed to capture the collective dimensions of various measures. Following this, the value of these measures was examined in real-life projects with an existing database of 149 projects.

Searching for a suitable dispersion measure led to the member index. The member index, the ratio of the number of sites to the total number of project team members across all sites, proved

best representation of geographic dispersion in the context of technological projects in our sample. The number of project team members should be considered in the light of the number of sites. Of seven dispersion measures, only one dispersion measure is correlated with member index. The reason could be that the technological organizations of the present database have set up controlling systems to handle dispersion. These systems have a wide range from use of expert project managers, high technical support to virtual meetings, or organizational support provided to virtual teams.

The combined measure of STR was found to be a good index for capturing dispersion. Therefore, team building processes should simultaneously consider the geographic distance between sites, specifically the distance between the project manager's site and other project sites and the number of time zones. It is remarkable that that the combination of spatial and temporal, or spatial and travel, or spatial and travel is not correlated with teamwork effectiveness It could be because of neutralizing the effect of each other in two-dimensional on the relation of these measures and teamwork effectiveness. A combined measure of SNR is also a suitable index. Hence, the geographic distance between sites, particularly the physical location of the sites in relation to the project manager's site as well as the number of sites should be considered together to foster more effective teamwork.

The travel and temporal indices also have a considerable relation with teamwork effectiveness. It is interesting to note that in the sample used for this research, the greater the travel index score, the more effective the teamwork; similarly, the greater the temporal dispersion, the greater the teamwork effectiveness. The negative correlation is due to the reverse function applied to the temporal index. This is probably because most of the organizations contacted for the questionnaire are large and mature companies. These mature organizations have already developed mechanisms for virtual team support. The relation of dispersion and teamwork effectiveness is not negative; as the traditional literature (Chudoba, 2005; Duxbury, 2010) would expect. The maturity of organizations and the technological support provided by them create a positive relationship between dispersion measures and teamwork effectiveness

The results of this study revealed the importance of project manager experience and managerial skills, suggesting that an expert project manager can offset the challenges of collaboration and

coordination among team members. The greater the project manager's expertise, the more effectively the team worked. This study responds to calls for research analyzing the effect of project manager experience and managerial skills.

The results also revealed the importance of virtual meetings in offsetting the negative relation of geographic dispersion with teamwork effectiveness.

Based on the results, team size has a negative relation with teamwork effectiveness. This is consistent with the studies of Hoegl (2005) and Espinosa et al. (2007).

Similarity of work methods has a positive relation with teamwork effectiveness, which is consistent with the works of Chudoba et al. (2005) and Lu et al. (2006).

Prior common experience of project team members did not have a significant relation with teamwork effectiveness, which failed to confirm the results of Huckman et al. (2009) and Staats (2012).

Organizational support and technological support both have a positive effect on teamwork effectiveness, confirming the results of studies by Hertel, Konradt, and Orlikowski (2004). Training, in general, and training in meetings and technology, in particular has a positive on effect on teamwork. Technological support and being equipped with collaboration tools also improve teamwork.

Face-to-face meetings did not have a significant relation with teamwork effectiveness. This is not consistent with the literature reviewed. This issue can be explained by the great geographic distance between the project sites studied here, making face-to-face meetings difficult.

5.2 Theoretical Implications

The degree of virtual dispersion is rarely studied in real-life projects. Many authors have provided different structures to capture this dimension (e.g. (O'Leary & Cummings). However, theoretical measures are rarely studied in ongoing real projects. The present study looks at the proposed measures using a sample of 149 real projects of considerable diversity in terms of geographic distance, time zones and organizational characteristics. The results are of practical use to both researchers and managers of virtual teams.

The concept of creating combined measures to capture the multi-dimensional nature of dispersion was first discussed by Hamel (2007). In her work, she used the combined measure of number of sites, difference of hours between the sites furthest from each other and the geographic distance of different sites from project manager's site, weighted by the total number of project team members. However, when trying to capture dispersion, she didn't compare the efficiency of measures.

In this study, the use of combined measures to represent the multi-dimensional nature of dispersion is studied in detail. Different combinations of dispersion measures—two and three at a time—are considered and evaluated based on the sample and the best measures are selected from among the combinations. These combined measures are the indicators of the reality of multi-dimensional nature of dispersion measures. The measures can be practically applied by researchers seeking good measures of the degree of virtual dispersion.

Many researchers have based their research on the spatial, temporal and configurational measures introduced by O'Leary and Cummings (2007). However, none of these measures are correlated with teamwork effectiveness in the current research. As mentioned in literature review, Cataldo and Nambier (2012) have considered the relation of these measures in their study but with a different output variable. This output variable is software quality. The dispersion measures revealed to impact negatively the software quality. Their sample contained the different context from ours; global software development projects. Both the concept and context are different from these of the current thesis. Hinds and Mortenson (2005) have also used the measures of O'Leary and Cummings (2007). However, they have studied the relation of these dispersion measures and conflict.They collected the data from the archival data of research and development of a firm in natural ressources extraction. Thay have uncovered the positive relationship of dispersion and conflict. In the context of technological projects with the various projects from different fields, the measures of O'Leary and Cummings are not correlated to teamwork effectiveness. There is a possibility that in a different context or with another output variable, the results would be different.

In response to the call by authors for study of the role of organizational, technological and project-based factors to reduce the negative impacts of dispersion (O'Leary & Cummings, 2007),

the effects of these factors on the relation of dispersion to teamwork effectiveness are analyzed. This study as a secondary result fills a void in the understanding of the effects of these organizational and technological factors on dispersion.

5.3 Managerial Implications

Based on the results of the present research, the major implications for managers are provided in this section. In the process of team building, project manager experience and managerial skills should be given special attention. The project manager attributes mentioned offset the negative effects of various kinds of dispersion on teamwork effectiveness. It is recommended that project managers have the necessary skills, including sufficient authority, problem solving and decision-making skills (Nemiro, 2008).

The second fact of interest to practitioners is that virtual meetings greatly reduce the feeling of dispersion. Practitioners should pay attention to the guidelines regarding amount of interaction, content of discussions and patterns of interactions (Anderson et al., 2007) provided by the authors for organizing structured meetings.

The third finding of interest is that the member index is an appropriate index for measuring the degree of virtual dispersion. Therefore, project managers should select the total number of people for their project in proportion to the number of sites. The relation of team size on teamwork effectiveness, however, proved to be negative. Larger teams have intrinsic communication and coordination challenges (Espinosa et al., 2007). Considering these two findings of the study, the optimal number of subgroups or project sites should be carefully considered by project managers.

When different dispersion measures have the same degree of importance, it is helpful to use combined measures. Managers are encouraged to make use combined measures, specifically the spatial, temporal and travel indices and spatial dispersion, number of sites and travel index. It should be noted that two by two combinations of dispersion measures are not as effective as three by three combinations. Practitioners should consider together the concept of geographic distance between the sites, particularly between the project manager’s and the other sites and the number of time zones. Another method could be to consider the geographic distance between the sites, especially between the project manager’s site and the other sites, at the same time.

The maturity of organizations involved in the project should also be considered by the project manager. The project manager who works with organizations that have developed the mechanisms of coordination and collaboration essential to teamwork effectiveness will have a very different experience than the project manager working with organizations that don't have the experience and mechanisms required to handle the challenges of dispersion. It is clear that the second situation will require much more of experience of the project manager.

5.4 Limitations

The sample for this research essay is mainly technological projects within mature organizations, which have attained the ability to handle virtual teams. Including small organizations would provide broader results.

The literature review of this research is limited to virtual teams. Therefore, the results of this research are valid for this context. In order to generalize the comparison of the dispersion measures, different contexts with various research communities should be considered.

The other limit to the research is that the database is gathered with just one member of each virtual team. This project member represents the whole team. To have more valid information, different members of team should be engaged in providing the information.

5.5 Suggestions for Future Work

The categorical index was used because of the wish to compare the effect of the degree of dispersion as a dichotomy (traditional definition of degree of virtual dispersion) on teamwork effectiveness rather than considering it as a continuous variable. In future research, it is suggested that the percentage of members outside the project manager's site be considered rather than dichotomizing this measure. It is probable that use of the dichotomized measure was the main reason that the connection between the categorical index and teamwork effectiveness was not significant.

The importance of the role of technological support and mechanisms of virtual team support was proven in this study. A recommended future avenue of research is analyzing the mediating effect of virtual team support mechanisms on the relationship between dispersion measures and

teamwork effectiveness. In other words, an investigation of whether virtual team mechanisms play a cause and effect role in the relation of dispersion measures to teamwork effectiveness could be undertaken. In the same vein, in order to keep constant the maturity of organization, the other interesting proposition for future is too choose one large company and study the relation of geographical measures of dispersion and teamwork effectiveness across the projects in this specific company.

In the present study, the relationship between certain dispersion measures and teamwork effectiveness was confirmed using certain project-based and organizational contextual factors. Another interesting subject of research would be to select another output variable, such as performance or decision-making quality and analyze the connection between measures of dispersion and this output variable with the same contextual factor.

In this study all dispersion measures are team based. In teams whose members change, this can be problematic. Researchers should consider the nature of the project to select the most appropriate measures of dispersion. The entity under study, according to O'Leary and Cummings (2007) might also be co-acting groups, networks or communities of practice.

The main framework of our survey was limited to the province of Quebec. Administering the survey in different provinces or to all of Canada would make it possible to compare more teams and give it external validity.

CONCLUSION

In today's competitive and fast-evolving markets, it is now acknowledged that firms' performance depends on networking with a wide range of local, national and international partners. This networking can take a variety of forms such as cooperative agreements, alliances, etc. In practice, these inter-organizational relationships require the implementation of structures, methods and tools to support effective teamwork. Numerous researchers have worked to identify the factors related to teamwork effectiveness of "virtual" or "distributed" teams, the definition of which, as the literature review shows, remains controversial.

One of the obstacles currently slowing the development of knowledge in this field is theoretical and methodological in nature: the concept of team "dispersion" remains vague and the structure to compare the dispersion measures is not studied yet.

To shed light on the concept of dispersion, the literature on studies of dispersion measures was reviewed. From the literature, the measures that were easy to use and compatible with real-life projects were chosen. From all the dispersion measures studied, spatial, temporal, site, member, travel, imbalance and categorical indices were selected.

Following this, the selected measures were evaluated based on an existing database of 149 real projects. The database was conducted by the Canada Research Chair on Technology Project Management at École Polytechnique and completed by project management professionals who were members or project managers of virtual teams. New measures, combined measures of dispersion, were also created to capture the multi-dimensional nature of dispersion using the cross product of simple dispersion measures. Thereafter, the relation of selected and created measures to teamwork effectiveness was verified, considering certain project-based and organizational contextual factors. These contextual factors included project team size, project manager managerial skills and experience, face-to-face and virtual meetings, organizational and technological support, and prior common experience of project team members.

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APPENDICES

APPENDIX A – LITERATURE REVIEW OF DIFFERENT GEOGRAPHICAL DISPERSION MEASURES ADMINISTRATED ON THE REAL-LIFE DATA FROM COMPANIES

Authors	**Data collection and sample caracteristics**	**Dimensions**	**Measurs**	**Results**
Cataldo & Nambiar, (2012)	Archival data from a company that produces embedded systems for the automotive industry Final sample: 189 projects	Spatial Dispersion Based on O'Leary and Cummings(2007)	N_i: number of people in site i; N_j: number of people in site j; N: number of all project members; ML_{ij}: distance in miles between site I and site j	Spatial dispersion was removed because of high correlation with temporal dispersion
		Temporal Dispersion Based on O'Leary and Cummings(2007)	$\bar{} \quad \bar{}$ N_i: number of people in site i; N_j: number of people in site j; N: number of all project members; TZ_{ij}: between site I and site j	Temporal dispersion found to have a negative impact on software quality
		Number of sites Based on O'Leary and Cummings(2007)	Number of different locations	Number of sites found to have a negative impact on software quality

		People-based dispersion	N_j: number of developers belonging to location j; N:total number of developers across all sites; n:number of sites	People dispersion found to have a negative impact on software quality
(Cummings & Haas, 2012)	2055 members of 285 teams in a large global corporation	Geographic dispersion(based on Olson and Olson, 1999)	Seven-point scale capturing increasing levels of physical separation 1=same room, 2=different room, 3=different hallway, 4=different floor, 5= different building, 6=different city, 7= different country	Any significant main effects of these alternative measures or any moderating effects on the relationship between time allocation and team performance
(Colazo & Fang, 2010)	Archival data from 100 development teams(open source system project teams)	Temporal dispersion (TD) using an "actual-work-hour-based" measure	TD was measured "using the variance in the team members' starting time, where time is expressed in a location-independent time unit UTC. For every day in a given time window immediately preceding the measurement of the other variables, the time when each developer submitted his first contribution was recorded"	• TD is positively associated with development speed • TD is positively associated with the quality of coding • Relationship between TD and quality of coding is moderated by software structural complexity
(Schweitzer & Duxbury, 2010)	Survey: 107 team members from 30 different teams within a large private sector technology firms	Proportion of team work time spent working virtually		Proportion of time spent working virtually significantly correlated (negatively) with two measures of effectiveness: satisfaction and member perception of VT performance

		Proportion of member virtuality		Proportion of member virtuality significantly correlated (negatively) with member perception of VT performance
		Degree of separation		Degree of distance between team members significantly correlated (negatively) with two measures of effectiveness: satisfaction and member perception of virtual teams performance
(Bierly et al., 2009)	Internet survey with various professional and technical associations. Final sample: 116 respondents representing 116 new product developments teams.	Virtuality : Degree with which team members interacted through computer and telecommunications technologies (from face-to-face to fully virtual) (based on Martins et al. (2004)	Three-item measure on 5-point Likert scale (Cronbach's alpha= 0.78) e.g. "we primarily interacted through computer and telecommunications technologies" was an item in the questionnaire	• Greater degrees of virtuality were found to exacerbate the negative association between relationship conflict and trust • Greater degrees of virtuality were found to reduce the importance of goal clarity in creating trust among members • Greater degree of virtuality were found to render trust less important in facilitating NPD team member cooperation
(Stark & Bierly Iii, 2009)	Internet survey with various professional and technical associations; Final sample: 178 respondents representing 178 new product developments teams.	Virtuality (as a moderating factor): Degree with which team members interacted through computer and telecommunications technologies (from face-t-face to fully virtual) (inspired from Martins et al. (2004)	Three-item measure on 5-point Likert scales (α=0,78)	• Preference for group work increases team satisfaction more as virtualness increases • Relationship conflict has a more devastating effect on team member satisfaction as virtualness increases • Goal clarity and familiarity are not moderated by the degree of virtualness but have a significant direct effect on team satisfaction
(Montoya et al., 2009)	Survey: 184 respondents from 15 teams of three sectors of design &	Team Virtuality: degree of team collocation	4 categories of virtuality considered (% of team collocation):	The three hypotheses are supported: • ICT use by virtual team members is contingent on task type, ICT type, and situational factors

	manufacturing including agriculture and construction equipment; information technologies; and residential and commercial flooring, ceiling, and cabinets.			• Distinct patterns of ICT use are related to task type and situational characteristics The different patterns of ICT use by virtual NPD team members are associated with different levels of perceived performance
(Staples & Webster, 2008)	Online survey: 824 participants	Imbalance index (based on O'Leary and Cummings, 2002)	Standard deviation of members per site divided by the size of the team	• No moderating effect between trust and knowledge sharing • A moderating effect (negative) found between knowledge sharing and performance
		Isolation index (based on O'Leary and Cummings, 2007)	Percent of team members who are at sites with one or no other teams members	• No moderating effect between trust and knowledge sharing; • No moderating effect between knowledge sharing and performance
		Time zone spread	Extent to which one needs to collaborate with team members in different time zones(based on Chudoba et al., 2005)	• No moderating effect between trust and knowledge sharing; • No moderating effect between knowledge sharing and performance
		Team stability	Extent to which one needs to work with changing team members(based on Chudoba et al., 2005)	• No moderating effect between trust and knowledge sharing; • No moderating effect between knowledge sharing and performance
		Lack of face-to-face knowledge	Extent to which one needs to collaborate with team members that have never met face-to-face (based on Chudoba et al., 2005)	• No moderating effect between trust and knowledge sharing; • No moderating effect between knowledge sharing and performance
		Language diversity	Extent to which one needs to collaborate with team members who speak different native language(based on Chudoba et al., 2005)	• No moderating effect between trust and knowledge sharing; • No moderating effect between knowledge sharing and performance

		Structural forms	• traditional team • virtual team • hybrid team	• No moderating effect between trust and knowledge sharing; • A moderating effect (negative) found between knowledge sharing and performance for hybrid teams
(Espinosa et al., 2007)	Archival data from software development teams from software production sources at a large telecommunications firm	Geographic Dispersion	This variable was dichotomized: 0 if all developers who completed deltas in an modification request project(software projects) worked in the same location and 1 otherwise.	We found that geographic dispersion and team size had a negative effect on performance. We also found that team familiarity helped to mitigate these negative effects: team familiarity helped narrow the performance difference between collocated and geographically dispersed teams.
(Hoegl & Proserpio, 2004)	145 software development teams from four German software development laboratories 430 participants	Proximity of Team Members	Four items, Cronbach's alpha 0.80. • Most members of my team worked directly in the vicinity, so that they could visit each other without much effort. • Team members were located too far from one another to move the project along expeditiously. • Only a few team members were easily reachable on foot. • It was at times problematic to get the team members together in one place for spontaneous meetings (e.g., for discussions and decisions).	Proximity among team members is positively associated with the quality of teamwork among them. Furthermore, five of the six facets of teamwork quality show the same relationship with team members' proximity
(Hoegl et al., 2007)	Responses from 575 managers, team leaders, and team members of 145 new product development	Proximity of Team Members	The same as Hoegl and Proserpio (2004)	The positive impact of teamwork quality on both team effectiveness and team efficiency in innovative projects increases with team members' decreasing proximity.

(Gibson & Gibbs, 2006)	First phase: qualitative analysis of interviews with 177 members of 14 teams in a variety of industries. Second phase: Survey data collected from 266 members of 56 aerospace design teams.	Geographic dispersion This measure takes into consideration both the number of locations and the number of individuals in the team residing in each location	The minimum value for this variable was 0, indicating that all members had the same location, and the maximum value was .85, indicating extreme geographic dispersion (e.g., 4 locations represented by approximately 2–3 members in each location), with a mean of 0.42 and a standard deviation of 0.35.	Results show that the four characteristics are not highly correlated, that they have independent and differential effects on innovation, and that a psychologically safe communication climate helps mitigate the challenges they pose.
		Electronic dependence: the extent to which members relied on three forms of electronic communication	This variable was measured by four items asking about the extent to which members relied on three forms of electronic communication (e-mail, teleconferencing, and collaborative software), as well as their overall reliance on electronic communication, using a 5-point scale (1 = not at all; 5 = to a very great extent). These four items loaded on a single factor with an eigenvalue of 2.06, accounting for 51 percent of the variance, with loadings ranging from 0.60 to 0.82. The reliability of this scale (alpha) was 0.72.	
		Dynamic structure	with three items (“Members of this team change frequently”; “It is difficult to know who is on this team and who is not”; and “We lack a consistent operating structure in this team.”) using a 5-point scale (1 = not at all; 5 = to a very great extent). These items loaded on a single factor with an eigenvalue of 1.81, accounting for 60 percent of the variance, with factor loadings ranging from 0.63 to 0.86. Reliability (alpha) was 0.70.	

		National diversity national diversity, following team heterogeneity research (Bantel and Jackson, 1989; Bunderson and Sutcliffe, 2002)	Blau's (1977) formula is used to calculate a measure of categorical dispersion across nationalities in each team. The minimum value for this variable was 0, indicating that all members had the same nationality, and the maximum value was .99, indicating extreme national diversity (e.g., 5 nationalities represented on the team with approximately 1–2 members of each nationality), with a mean of 0.26 and a standard deviation of 0.34.	
(Cramton & Webber, 2005)	Survey: 218 respondents from 39 work teams (international consulting firm specializing in the delivery of customized software and systems integration)	Geographical Dispersion	Geographic dispersion was assessed by coding teams into one of two categories based on interviews with team leaders: (1) teams with collocated members, whose members all work out of the same office and (2) teams with geographically dispersed members, in which at least 30% of the members work out of offices at one or more locations separate from the others.	• Teams with geographically dispersed members have less effective work processes than teams with collocated members. • Geographic dispersion has a significant negative relationship with perceived performance • Team processes do partially mediate the relationship between geographic dispersion and perceived performance.
(Lu et al., 2006) (Chudoba et al., 2005)	Survey: 1269 employees from different Intel company sites	Team Dispersion	• Collaborate with people in different time zones • Work with people via internet-based conferencing applications • Collaborate with people who have never met face-to-face • Collaborate with people who speak different languages or dialects from your own	No significant relationships between team dispersion and team performance

		Workplace mobility	• Work at different sites • Have professional interactions with people outside the organization • Work at home during normal days • Work while travelling e.g. at airports or hotels	• Workplace mobility found to have negative impact on only one dimension of communication: "focus on right questions" • Workplace mobility negatively impacted performance
		Variety of methods	Work on projects that have changing team members Work with teams that have different ways to track their work Work with people that use different collaboration technologies	• Variety of methods negatively impacted performance. •Variety of methods found to have negative impact on various aspect of team communication: communication of ideas and focused team discussion, team members' meeting commitment, equal opportunity to contribute, trust, and risk taking
(Hinds & Mortensen, 2005)		Number of sites based on O'Leary and Cummings, (2002)	Authors used self-report data (verified against the company database) to identify each respondent's office location.	Exploratory factor analysis to create two groups of dispersion • Structural aspects of dispersion including: Separation (physical distance) Number of sites and lack of time zone overlap • Psychological aspects of dispersion including: Percentage of isolates Imbalance index Shared identity, shared context, and spontaneous communication all moderated the relationship between dispersion and conflict.
	Research setting: the R&D arm of a firm in the natural resources extraction and processing industry. final sample consists of 43 teams with a total of 288 responses based on O'Leary and Cummings, (2002)	Percentage of isolates	Authors used self-report data (verified against the company database) to identify each respondent's office location.	
		Imbalance index	Authors used self-report data (verified against the company database) to identify each respondent's office location.	
		Separation (physical distance)	Authors used self-report data (verified against the company database) to identify each respondent's office location.	

		lack of time zone overlap	self-report data (verified with the company database) to identify each respondent's office location.	
(Herbsleb & Mockus, 2003)	• Research setting: Two department of a global telephone company (offices in United States, Europe and Asia) • Data 1: Archival data (modification requests); • Data 2: survey: 98 surveyed employees (phase 1) and 96 employees (phase 2)	Virtual change	changes involving people from more than one site	
(McDonough et al., 2001)	Survey: 103 questionnaires from members of the Product Development and Management Association	3 ordinal categories: collocated, virtual (same country), global (several countries)	Co-located teams: comprised of individuals who work together in the same physical location and are culturally similar • Virtual teams: comprised of individuals who have a moderate level of physical proximity and are culturally similar. • Global teams: comprised of individuals who work and live in different countries and are culturally diverse	• Behavioral challenges not found to be associated with project performance • Project management challenges shown to have a negative relationship with performance • Type of firms not shown to have a moderating effect on the relationships between independent variables (behavioral and PM challenges) and project performance

APPENDIX B – CORRELATION OF COMBINES MEASURES AND TEAMWORK EFFECTIVENESS

	Teamwork effectiveness
Two-by-two Indices	**Correlation**
Spatial index & Temporal index	-0.003
[illegible]	[illegible]
[illegible]	[illegible]
Spatial index & Travel index	-0.001
Spatial index & Imbalance index	-0.091
[illegible]	[illegible]
[illegible]	[illegible]
Temporal index & Member index	-0.064
[illegible]	[illegible]
[illegible]	[illegible]
Temporal index & Categorical index	-0.065
[illegible]	[illegible]
Site index &Travel index	-0.067
Site index & Imbalance index	-0.050
[illegible]	[illegible]
Member index & Travel index	-0.009
[illegible]	[illegible]
[illegible]	[illegible]
Travel index & Imbalance index	-0.089
[illegible]	[illegible]
Imbalance index & Categorical index	-0.054

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

Teamwork effectiveness	
Three-by-three Indices	**Correlation**
Spatial index & Temporal index & Site index	-0.066
Spatial index & Temporal index & Member index	-0.071
Spatial index & Temporal index & Travel index	-0.136
Spatial index & Temporal index & Imbalance index	-0.008
Spatial index & Temporal index & Categorical index	0.098
Spatial index & Site index& Member index	0.032
Spatial index & Site index& Travel index	0.121
Spatial index & Site index& Imbalance index	-0.070
Spatial index & Site index& Categorical index	0.055
Spatial index & Member index& Travel index	-0.045
Spatial index & Member index& Imbalance index	-0.020
Spatial index & Member index& Categorical index	-0.007

Spatial index & Travel index& Imbalance Index	-0.046
Spatial index & Travel index& Categorical index	-0.042
Spatial index & Imbalance index& Categorical index	-0.014
Temporal index& Site index& Member index	-0.116
Temporal index& Site index& Travel index	-0.055
Temporal index& Site index& Imbalance index	0.049
Temporal index& Site index& Categorical index	-0.004
Temporal index& Member index& Travel index	0.015
Temporal index& Member index& Imbalance index	0.115
Temporal index& Member index& Categorical index	-0.048
Temporal index& Travel index& Imbalance index	-0.045
Temporal index& Travel index& Categorical index	0.128
Temporal index& Imbalance index& Categorical index	-0.032
Site index& Member index&	0.035

Travel index	
Site index& Member index& Imbalance index	-0.112
Site index & Member index & Categorical index	-00.001
Site index & Travel index & Imbalance index	0.009
Site index & Travel index & Categorical index	-0.049
Site index & Imbalance index & Categorical index	0.031
Member index & Travel index & Imbalance index	-0.116
Member index & Travel index & Categorical index	0.096
Member index & Imbalance index & Categorical index	-0.024
Travel index & Imbalance index& Categorical index	0.012

1. two-tailed test of partial correlations with* P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

APPENDIX C – CORRELATION OF COMBINED DISPERSION MEASURES AND TEAMWORK EFFECTIVENESS CONTROLLED BY ALL MEASURES OF DISPERSION

	Teamwork effectiveness
Two-by-two Indices	**Correlation**
Spatial index & Temporal index	0.024
Spatial index & Site index	0.109
Spatial index & Member index	0.007
Spatial index & Travel index	0.003
Spatial index & Imbalance index	-0.072
Spatial index & Categorical index	0.030
Temporal index & Site index	-0.024
Temporal index & Member index	-0.047
Temporal index &Travel index	0.014
Temporal index & Imbalance index	0.050
Temporal index & Categorical index	-0.058
Site index & Member index	0.036
Site index &Travel index	-0.044
Site index & Imbalance index	0.048
Site index & Categorical index	0.079
Member index & Travel index	-0.032
Member index & Imbalance index	0.100
Member index & Categorical index	0.036
Travel index & Imbalance index	-0.093
Travel index & Categorical index	0.082
Imbalance index & Categorical index	-0.072

Teamwork effectiveness	
Three-by-three Indices	**Correlation**
Spatial index & Temporal index & Site index	-0.063
Spatial index & Temporal index & Member index	-0.085
Spatial index & Temporal index & Travel index	*-0.154**
Spatial index & Temporal index & Imbalance index	0.060
Spatial index & Temporal index & Categorical index	0.078
Spatial index & Site index& Member index	-0.009
Spatial index & Site index& Travel index	0.074
Spatial index & Site index& Imbalance index	-0.037
Spatial index & Site index& Categorical index	0.016
Spatial index & Member index& Travel index	-0.017
Spatial index & Member index& Imbalance index	0.002
Spatial index & Member index& Categorical index	0.000
Spatial index & Travel index&	0.012

Imbalance Index	
Spatial index & Travel index& Categorical index	-0.102
Spatial index & Imbalance index& Categorical index	0.031
Temporal index& Site index& Member index	-0.078
Temporal index& Site index& Travel index	-0.014
Temporal index& Site index& Imbalance index	0.022
Temporal index& Site index& Categorical index	0.010
Temporal index& Member index& Travel index	-0.040
Temporal index& Member index& Imbalance index	0.087
Temporal index& Member index& Categorical index	-0.034
Temporal index& Travel index& Imbalance index	-0.052
Temporal index& Travel index& Categorical index	0.117
Temporal index& Imbalance index& Categorical index	-0.056
Site index& Member index& Travel index	-0.002

Site index& Member index& Imbalance index	-0.127
Site index & Member index & Categorical index	0.011
Site index & Travel index & Imbalance index	0.006
Site index & Travel index & Categorical index	-0.059
Site index & Imbalance index & Categorical index	0.070
Member index & Travel index & Imbalance index	-0.077
Member index & Travel index & Categorical index	0.074
Member index & Imbalance index & Categorical index	0.000
Travel index & Imbalance index& Categorical index	0.053

1. two-tailed test of partial correlations with * P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

APPENDIX D – CORRELATION OF COMBINED DISPERSION MEASURES AND TEAMWORK EFFECTIVENESS CONSIDERING THE CONTEXTUAL FACTORS

	Teamwork effectiveness						
Combined measures Two-by-two	**Experience and skills**	**Similarity of work**	**Prior common experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index & Temporal index	0.027	0.013	-0.008	-0.018	-0.021	0.005	-0.016
Spatial index & Site index	-0.002	0.036	0.067	0.037	0.074	0.061	0.064
Spatial index & Member index	-0.023	0.001	0.026	0.047	0.005	0.026	0.035
Spatial index & Travel index	0.000	0.003	0.000	0.017	0.030	-0.017	0.002
Spatial index & Imbalance index	-0.033	-0.080	-0.094	-0.025	-0.094	-0.095	-0.022
Spatial index & Categorical index	-0.053	0.040	0.039	-0.028	0.044	0.027	0.000
Temporal index & Site index	0.028	0.063	0.013	0.032	-0.020	0.018	-0.007
Temporal index & Member index	-0.055	0.000	-0.064	-0.013	-0.079	-0.061	-0.045
Temporal index &Travel index	0.018	0.013	0.043	-0.004	0.018	0.044	0.012
Temporal index & Imbalance index	0.080	0.048	0.072	-0.012	0.090	0.067	0.030
Temporal index &	-0.025	-0.055	-0.074	-0.011	-0.106	-0.066	-0.061

Categorical index							
Site index & Member index	0.019	0.078	0.060	-0.029	0.035	0.059	0.067
Site index &Travel index	-0.077	-0.075	-0.066	-0.035	-0.034	-0.082	-0.065
Site index & Imbalance index	-0.041	-0.041	-0.052	-0.047	-0.041	-0.052	-0.044
Site index & Categorical index	0.057	0.101	0.124	0.096	0.071	0.111	0.095
Member index & Travel index	0.023	0.003	-0.010	0.009	-0.004	-0.014	0.041
Member index & Imbalance index	0.145	0.096	0.084	0.130	0.072	0.080	0.031
Member index & Categorical index	-0.071	0.039	0.036	-0.038	0.006	0.030	0.036
Travel index & Imbalance index	-0.097	-0.071	-0.093	-0.101	-0.095	-0.092	-0.072
Travel index & Categorical index	0.026	0.034	0.064	0.087	0.065	0.050	0.087
Imbalance index & Categorical index	0.019	-0.022	-0.056	-0.054	-0.035	-0.060	-0.050

1. two-tailed test of partial correlations with * P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

	Teamwork effectiveness						
Combined measures Three-by-three	**Experience and skills**	**Similarity of work**	**Prior common experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index & Temporal index & Site index	-0.004	-0.078	-0.065	-0.081	-0.070	-0.076	-0.052
Spatial index & Temporal index & Member index	-0.035	-0.070	-0.070	-0.014	-0.049	-0.092	-0.095
Spatial index & Temporal index & Travel index	-0.032	-0.107	-0.140	-0.124	-0.142	-0.123	-0.118
Spatial index & Temporal index & Imbalance index	-0.038	0.005	-0.015	-0.050	0.015	0.003	-0.020
Spatial index & Temporal index & Categorical index	0.103	0.075	0.105	0.132	0.079	0.104	0.108
Spatial index & Site index& Member index	-0.014	0.016	0.031	-0.036	0.059	0.034	0.035
Spatial index & Site index& Travel index	0.049	0.088	0.124	***0.163****	0.104	0.141	0.117
Spatial index & Site index& Imbalance index	-0.042	-0.041	-0.074	-0.144	-0.078	-0.072	-0.069
Spatial index & Site index& Categorical index	0.087	0.023	0.055	0.114	0.051	0.066	0.051
Spatial index & Member index& Travel index	-0.073	-0.047	-0.047	-0.127	-0.055	-0.026	-0.025
Spatial index & Member index& Imbalance index	-0.005	-0.033	-0.024	-0.052	-0.030	-0.018	-0.025
Spatial index & Member index& Categorical index	0.035	0.018	-0.007	-0.046	0.013	0.000	-0.006

Spatial index & Travel index& Imbalance Index	0.038	-0.015	-0.043	-0.037	-0.042	-0.062	-0.039
Spatial index & Travel index& Categorical index	-0.041	-0.083	-0.051	0.014	-0.032	-0.040	-0.051
Spatial index & Imbalance index& Categorical index	-0.038	0.005	-0.013	-0.082	0.004	-0.015	-0.010
Temporal index& Site index& Member index	-0.027	-0.105	-0.114	-0.058	-0.115	-0.118	-0.118
Temporal index& Site index& Travel index	-0.024	-0.030	-0.058	-0.105	-0.047	-0.062	-0.053
Temporal index& Site index& Imbalance index	-0.017	0.019	0.050	0.103	0.047	0.052	0.049
Temporal index& Site index& Categorical index	-0.005	0.014	-0.003	-0.048	0.023	-0.005	0.002
Temporal index& Member index& Travel index	0.085	0.005	0.014	0.053	0.025	0.003	-0.001
Temporal index& Member index& Imbalance index	0.121	0.091	0.113	0.070	0.116	0.112	0.111
Temporal index& Member index& Categorical index	-0.021	-0.057	-0.047	0.012	-0.017	-0.046	-0.044
Temporal index& Travel index& Imbalance index	-0.092	-0.048	-0.049	-0.004	-0.027	-0.036	-0.050
Temporal index& Travel index& Categorical index	0.093	0.145	0.140	0.048	0.090	0.128	0.135
Temporal index& Imbalance index& Categorical index	-0.049	-0.044	-0.038	0.011	-0.058	-0.031	-0.044
Site index& Member index&	0.036	0.013	0.035	-0.054	0.044	0.043	0.025

Travel index							
Site index& Member index& Imbalance index	-0.097	-0.114	-0.114	-0.064	-0.071	-0.119	-0.113
Site index & Member index & Categorical index	0.045	-0.021	-0.005	0.024	0.016	0.011	-0.005
Site index & Travel index & Imbalance index	0.061	0.012	0.011	-0.034	-0.040	0.010	0.002
Site index & Travel index & Categorical index	-0.020	-0.042	-0.052	-0.060	-0.029	-0.036	-0.048
Site index & Imbalance index & Categorical index	-0.025	0.001	0.031	0.030	0.009	0.035	0.030
Member index & Travel index & Imbalance index	-0.143	-0.118	-0.118	-0.109	-0.079	-0.113	-0.125
Member index & Travel index & Categorical index	0.117	0.091	0.097	0.071	0.059	0.109	0.097
Member index & Imbalance index & Categorical index	-0.106	-0.023	-0.026	-0.053	-0.024	-0.023	-0.026
Travel index & Imbalance index& Categorical index	0.054	0.010	0.017	0.032	0.024	0.017	0.016

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

APPENDIX E – CORRELATION OF EACH COMBINED DISPERSION MEASURE AND TEAMWORK EFFECTIVENESS CONTROLLED BY ALL OTHER MEASURES AND A CONTEXTUAL FACTOR

	Teamwork effectiveness						
Combined measures Two-by-two	**Experience and skills**	**Similarity of work**	**Prior common experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index & Temporal index	0.031	0.029	0.013	0.010	0.009	0.040	0.023
Spatial index & Site index	0.016	0.077	0.122	0.084	0.114	0.108	0.104
Spatial index & Member index	-0.031	-0.008	0.012	0.029	-0.004	0.011	0.017
Spatial index & Travel index	0.006	0.006	0.006	0.030	0.027	-0.021	-0.002
Spatial index & Imbalance index	-0.028	-0.068	-0.079	-0.011	-0.082	-0.079	-0.065
Spatial index & Categorical index	-0.056	0.035	0.041	-0.034	0.042	0.019	0.027
Temporal index & Site index	0.008	0.018	-0.051	-0.005	-0.049	-0.030	-0.030
Temporal index & Member index	-0.044	-0.001	-0.044	0.006	-0.063	-0.042	-0.049
Temporal index &Travel index	-0.007	-0.004	0.011	-0.037	-0.003	0.014	0.015
Temporal index & Imbalance index	0.080	0.041	0.063	-0.035	0.067	0.049	0.051
Temporal index & Categorical index	-0.029	-0.053	-0.074	0.007	-0.088	-0.057	-0.061
Site index & Member index	0.019	0.055	0.028	-0.052	0.017	0.034	0.036
Site index & Travel index	-0.068	-0.059	-0.038	-0.014	-0.020	-0.068	-0.037
Site index & Imbalance index	0.002	0.036	0.057	0.032	0.025	0.047	0.042

Site index & Categorical index	0.013	0.069	0.102	0.062	0.052	0.078	0.079
Member index & Travel index	-0.005	-0.018	-0.034	-0.015	-0.023	-0.039	-0.030
Member index & Imbalance index	0.150	0.108	0.111	0.153	0.086	0.098	0.099
Member index & Categorical index	-0.079	0.035	0.042	-0.042	0.014	0.037	0.033
Travel index & Imbalance index	-0.095	-0.078	-0.099	-0.090	-0.098	-0.101	-0.090
Travel index & Categorical index	0.024	0.053	0.093	0.094	0.083	0.071	0.080
Imbalance index & Categorical index	0.027	-0.037	-0.081	-0.087	-0.066	-0.094	-0.072

1. two-tailed test of partial correlations with *P<0.10, ** P<0.05, *** P<0.01, **** P<0.00

	Team work effectiveness						
Combined measures Three by three	**Experience and skills**	**Similarity of work**	**Prior common experience**	**Support-ORG**	**Support-TECH**	**Face-to-face meetings**	**Virtual meetings**
Spatial index & Temporal index & Site index	-0.008	-0.077	-0.062	-0.093	-0.065	-0.070	-0.055
Spatial index & Temporal index & Member index	-0.040	-0.082	-0.079	-0.022	-0.063	-0.113	-0.099
Spatial index & Temporal index & Travel index	-0.041	-0.125	***-0.164****	-0.144	***-0.154****	-0.131	-0.136
Spatial index & Temporal index & Imbalance index	-0.014	0.058	0.047	0.017	0.067	0.079	0.052
Spatial index & Temporal index & Categorical index	0.082	0.061	0.093	0.114	0.074	0.094	0.084

Spatial index & Site index& Member index	-0.022	-0.008	-0.017	-0.080	0.013	-0.011	-0.004
Spatial index & Site index& Travel index	0.030	0.059	0.077	0.136	0.064	0.094	0.073
Spatial index & Site index& Imbalance index	-0.028	-0.007	-0.045	-0.118	-0.041	-0.038	-0.039
Spatial index & Site index& Categorical index	0.075	0.001	0.013	0.088	0.014	0.030	0.016
Spatial index & Member index& Travel index	-0.057	-0.024	-0.021	-0.117	-0.031	0.007	-0.001
Spatial index & Member index& Imbalance index	-0.007	-0.019	-0.012	-0.031	0.000	0.011	-0.005
Spatial index & Member index& Categorical index	0.057	0.026	-0.001	-0.040	0.009	0.005	0.002
Spatial index & Travel index& Imbalance Index	0.060	0.025	0.023	-0.010	0.003	-0.005	0.016
Spatial index & Travel index& Categorical index	-0.066	-0.124	-0.121	-0.023	-0.083	-0.103	-0.107
Spatial index & Imbalance index& Categorical index	-0.020	0.035	0.036	-0.045	0.048	0.034	0.031
Temporal index& Site index& Member index	-0.021	-0.080	-0.068	-0.023	-0.080	-0.080	-0.081
Temporal index& Site index& Travel index	-0.005	-0.006	-0.019	-0.077	-0.011	-0.020	-0.017
Temporal index& Site index& Imbalance index	-0.033	0.005	0.021	0.078	0.025	0.027	0.024
Temporal index& Site index&	0.008	0.021	0.013	-0.036	0.034	0.009	0.011

Categorical index							
Temporal index& Member index& Travel index	0.064	-0.034	-0.047	0.014	-0.018	-0.061	-0.047
Temporal index& Member index& Imbalance index	0.107	0.076	0.077	0.048	0.095	0.081	0.087
Temporal index& Member index& Categorical index	-0.013	-0.044	-0.031	0.024	-0.009	-0.033	-0.032
Temporal index& Travel index& Imbalance index	-0.093	-0.053	-0.060	0.007	-0.037	-0.041	-0.055
Temporal index& Travel index& Categorical index	0.083	0.133	0.138	0.038	0.093	0.123	0.121
Temporal index& Imbalance index& Categorical index	-0.072	-0.060	-0.072	-0.003	-0.075	-0.057	-0.060
Site index& Member index& Travel index	0.027	-0.010	-0.007	-0.081	0.013	0.006	-0.007
Site index& Member index& Imbalance index	-0.111	-0.129	-0.136	-0.077	-0.081	-0.134	-0.129
Site index & Member index & Categorical index	0.065	-0.002	0.002	0.043	0.019	0.021	0.013
Site index & Travel index & Imbalance index	0.059	0.008	0.010	-0.108	-0.030	0.012	0.000
Site index & Travel index & Categorical index	-0.012	-0.045	-0.066	-0.062	-0.046	-0.046	-0.055
Site index & Imbalance index & Categorical index	-0.024	0.032	0.074	0.064	0.048	0.088	0.068
Member index & Travel index & Imbalance index	-0.130	-0.091	-0.075	-0.072	-0.052	-0.069	-0.086

Member index & Travel index & Categorical index	0.098	0.073	0.075	0.047	0.050	0.096	0.076
Member index & Imbalance index & Categorical index	-0.115	-0.011	-0.003	-0.025	0.009	0.010	-0.002
Travel index & Imbalance index& Categorical index	0.069	0.041	0.063	0.054	0.055	0.066	0.055

1. two-tailed test of partial correlations with* P<0.10, ** P<0.05, *** P<0.01, **** P<0.001

APPENDIX F – COPY OF THE QUESTIONNAIRE

INTRODUCTON

1. Ce questionnaire porte sur les pratiques de gestion de projets dans un contexte où des membres de l'équipe travaillent physiquement à des endroits ou sur des sites différents. Dans le cadre de cette recherche, **nous appelons cette équipe : « *l'équipe dispersée* »** (certains peuvent l'appeler *équipe virtuelle*, *équipe délocalisée* ou encore, *équipe distribuée*).

2. Répondez au questionnaire en pensant à un projet récent auquel vous avez participé et qui fut réalisé par une équipe dispersée. Idéalement, ce projet devrait être terminé ou sur le point de se terminer. Répondez toujours en fonction de ce projet. Si vous avez agi à titre de consultant pour gérer le projet d'un client, répondez en fonction de ce projet.

3. La plupart des questions portent sur le projet et l'équipe de projet. À l'occasion, certaines questions sont posées sur votre organisation ou celle du client. Si vous travaillez pour une grande entreprise, répondez à ces questions en considérant l'unité administrative (division, filiale, succursale, etc.) directement concernée par ce projet et pour laquelle vous avez suffisamment de connaissances. Considérez alors cette unité administrative comme votre «organisation».

NATURE DU PROJET

1. De quel type de projet s'agit-il (*cochez*) ?

- ☐ conception d'un nouveau produit, service ou système
- ☐ amélioration d'un produit, service ou système existant
- ☐ implantation d'une technologie (technologie de production, système d'information, etc.)
- ☐ amélioration d'un processus construction, aménagement, …
- ☐ recherche et développement
- ☐ autre (spécifiez) :

2. Expliquez brièvement la nature du projet (objectifs, résultats attendus) :

3. Coût total du projet (approximativement) $CDN

4. Durée totale du projet : mois

5. Pour quel type d'organisation ce projet fut-il réalisé (*cochez*)?

- ☐ une entreprise privée
- ☐ une organisation publique ou
- ☐ para-publique autre (*spécifiez)*

B- LES ACTEURS DU PROJET

VOTRE RÔLE DANS L'ÉQUIPE

1. Quel était votre statut par rapport au « client » du projet *(cochez)* ?

   ☐ J'étais employé d'une unité administrative faisant partie de la même organisation que le « client » (projet interne)
   ☐ J'étais consultant externe mandaté par le « client »
   ☐ J'étais employé d'un sous-traitant / d'un fournisseur / d'un entrepreneur impliqué dans l'équipe de projet
   ☐ Autre statut (spécifiez):

2. Quel était votre rôle dans ce projet ? (cochez ce qui applicable)

   ☐ Responsable du projet (directeur, chef de projet, etc.)
   ☐ Spécialiste technique (ingénieur, informaticien, architecte, scientifique, etc.)
   ☐ Spécialiste de la gestion et du support au projet (planification, finances, comptabilité, contrats, etc.)
   ☐ Autre rôle (précisez) :

3. Combien d'heures avez-vous consacré à ce projet, par semaine? heures

4. Combien d'années d'expérience avez-vous dans votre secteur d'activités ? années

5. Combien d'années d'expérience avez-vous en gestion de projets ? années

6. Quelle est votre formation de base (cochez) :

   ☐ Sciences pures et appliquées (génie, informatique, sciences, …)
   ☐ Sciences de la gestion (finances, gestion des opérations, TI, ressources humaines, marketing, etc.)
   ☐ Sciences sociales et humanités, autre que sciences de la gestion
   ☐ Autre formation:

7. Avez-vous déjà reçu une formation académique en gestion de projets ou dans un domaine connexe? (cochez toutes les réponses applicables)

☐ Diplôme de deuxième cycle en gestion de projet
☐ (DESS, maîtrise, etc.)
☐ MBA
☐ Formation professionnelle ou séminaires
Certification du Project Management Institute (PMP)
Autre formation:

6. Où se trouvait physiquement le RESPONSABLE du projet par rapport à la MAJORITÉ DES MEMBRES de l'équipe dispersée ?

(cochez oui ou non)	Oui	Non
Dans le même édifice que l'équipe ?	☐	☐
Dans la même ville que l'équipe ?	☐	☐
Dans la même province/état que l'équipe ?	☐	☐
Dans le même pays que l'équipe?	☐	☐

7. Où se trouvait physiquement le RESPONSABLE du projet par rapport à la Direction de son organisation (« ses patrons ») ?

(cochez oui ou non)	Oui	Non
Dans le même édifice que sa Direction?	☐	☐
Dans la même ville que sa Direction?	☐	☐
Dans la même province/état que sa Direction?	☐	☐
Dans le même pays que sa Direction?	☐	☐

8. Où se trouvait physiquement le RESPONSABLE de l'équipe par rapport au CLIENT ?

(cochez oui ou non)	Oui	Non
Dans le même édifice que le client?	☐	☐
Dans la même ville que le client?	☐	☐
Dans la même province/état que le client?	☐	☐
Dans le même pays que le client?	☐	☐

9. Au total, combien d'organisations étaient directement impliquées dans ce projet?
(Répondez en fournissant la répartition dans le tableau)

Exemple

ORGANISATION	NOMBRE
le client	
divisions ou filiales du client	
sous-traitants et fournisseurs	
consultants	
autres organisations	

ORGANISATION	NOMBRE
le client	1
divisions ou filiales du client	1
sous-traitants et fournisseurs	5
consultants	1
autres organisations	3

Au sein de l'équipe, il y avait des différences ……	1	2	3	4	5	6	7	Pas en mesure de répondre
1. … de culture nationale								
2. ….de langue de travail	☐	☐	☐	☐	☐	☐	☐	☐
3. … de formation académique	☐	☐	☐	☐	☐	☐	☐	☐
4. … de compétences techniques	☐	☐	☐	☐	☐	☐	☐	☐
5. … d'horaires de travail	☐	☐	☐	☐	☐	☐	☐	☐
6. … de méthodes de travail	☐	☐	☐	☐	☐	☐	☐	☐
7. … d'outils de communication	☐	☐	☐	☐	☐	☐	☐	☐
8. ... dans la façon dont sont prises les décisions	☐	☐	☐	☐	☐	☐	☐	☐
9. … dans la façon de gérer les conflits	☐	☐	☐	☐	☐	☐	☐	☐

Au sein de l'équipe …	Tout à fait EN DÉSACCORD 1	2	3	4	5	6	Tout à fait EN ACCORD 7	Pas en mesure de répondre
1. … la majorité des membres avait déjà travaillé ensemble	☐	☐	☐	☐	☐	☐	☐	☐
2. ….la majorité des membres avait de l'expérience de travail en équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
3. … il y avait un bon climat de confiance au sein de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐

11. À quelle fréquence l'équipe dispersée a-t-elle tenu des réunions ?
(cochez et indiquez le nombre de fois)

☐ Régulièrement, c'est-à-dire fois par mois
OU
☐ Occasionnellement, environ fois pendant toute la durée du projet
OU
☐ Jamais

12. À quelle fréquence l'équipe dispersée s'est-elle réunie, au complet, sur un même site (réunions face à face) ?
(cochez et indiquez le nombre de fois)

☐ Régulièrement, c'est-à-dire fois par mois
OU
☐ Occasionnellement, environ fois pendant toute la durée du projet
OU
☐ Jamais

13. Y a-t-il eu une réunion de lancement (« kick-off ») en face à face avec toute l'équipe ? ☐ oui ☐ non

14. Au niveau de l'équipe, combien d'heures y avait-il entre les fuseaux horaires les plus éloignés ?
(exemple, entre Montréal et Londres : 5 heures)

LE CLIENT

NOTE : SI VOUS ËTES VOUS-MËME « CLIENT » DU PROJET, IGNOREZ LES QESTIONS 1 à 3

	JAMAIS						SOUVENT	Pas en mesure de répondre
	1	2	3	4	5	6	7	
1. Aviez-vous déjà travaillé pour ce client dans le passé ?	☐	☐	☐	☐	☐	☐	☐	☐

	TRÈS FAIBLE PROBABILITÉ						TRÈS FORTE PROBABILITÉ	Pas en mesure de répondre
	1	2	3	4	5	6	7	
2. Pensez-vous réaliser d'autres projets pour ce client dans le futur ?	☐	☐	☐	☐	☐	☐	☐	☐

	PEU important			MÊME impor-tance			TRÈS important	Pas en mesure de répondre
	1	2	3	4	5	6	7	
3. Quelle est l'importance de ce client par rapport à vos autres clients?	☐	☐	☐	☐	☐	☐	☐	☐

	Beaucoup PLUS PETITE			Taille similaire			Beaucoup PLUS GRANDE	Pas en mesure de répondre
	1	2	3	4	5	6	7	
4. Quelle taille (chiffre d'affaires) avait l'organisation du client par rapport à votre propre organisation?	☐	☐	☐	☐	☐	☐	☐	☐

5. Parmi les secteurs suivants (classification de Statistique Canada), lesquels décrivent le mieux le CLIENT du projet?

SCIAN 22 Services Publics (électricité, gaz et eau) SCIAN 23 Construction
SCIAN 31-33 Fabrication
SCIAN 41-45 Commerce de gros ou de détail SCIAN 52 Finance et assurances

SCIAN 54 Services professionnels, scientifiques et techniques SCIAN 62 Soins de santé et assistance sociale
SCIAN 71 Arts, spectacles et loisirs SCIAN 91 Administrations publiques Autre (spécifiez)

6. Est-ce que l'organisation du client détient une certification relative aux processus d'affaires (ISO, CMMI, HACCP, etc.)

Non
Si oui, laquelle / lesquelles? Je ne sais pas

C – LES CARACTÉRISTIQUES DU PROJET

En considérant les limites inférieure et supérieure suggérées, encerclez le chiffre (1 à 7) qui correspond le mieux à votre perception du projet.

1. COMPLEXITÉ

	1	2	3	4	5	6	7	
Ce projet était considéré SIMPLE par rapport aux projets habituels réalisés par l'équipe	☐	☐	☐	☐	☐	☐	☐	Ce projet était COMPLEXE par rapport aux projets habituels

2. ENVERGURE DU PROJET (coût, échéancier)

	1	2	3	4	5	6	7	
L'envergure de ce projet était BEAUCOUP plus PETITE que ceux réalisés habituellement par l'équipe	☐	☐	☐	☐	☐	☐	☐	L'envergure de ce projet était BEAUCOUP plus IMPORTANTE que ceux réalisés habituellement par l'équipe

3. SAVOIR-FAIRE

	1	2	3	4	5	6	7	
Le projet faisait appel à des technologies et savoir-faire COURANTS au sein de l'équipe	☐	☐	☐	☐	☐	☐	☐	Le projet faisait appel à des technologies et savoir-faire TOTALEMENT NOUVEAUX au sein de l'équipe

4. TECHNOLOGIE

	1	2	3	4	5	6	7	
Les technologies requises pour gérer ce projet N'ONT PAS CHANGÉ en cours de projet	☐	☐	☐	☐	☐	☐	☐	Les technologies requises pour gérer ce projet ONT CONSTAMMENT CHANGÉ en cours de projet

5. STABILITÉ DES EXIGENCES

	1	2	3	4	5	6	7	
Les exigences initiales sont demeurées STABLES tout au long du projet	☐	☐	☐	☐	☐	☐	☐	Les exigences initiales ont CONSTAMMENT CHANGÉ en cours de projet

6. STABILITÉ DU BUDGET

	1	2	3	4	5	6	7	
Le budget est demeuré STABLE tout au long du projet	☐	☐	☐	☐	☐	☐	☐	Le budget A FLUCTUÉ tout au long du projet

7. STABILITÉ DE L'ÉCHÉANCIER

	1	2	3	4	5	6	7	
L'échéancier est demeuré STABLE tout au long du projet	☐	☐	☐	☐	☐	☐	☐	L'échéancier A FLUCTUÉ tout au long du projet

D – ACTEURS ET PRISE DE DÉCISION

De qui relève la décision FINALE relativement …	Client	Experts techniques	Responsable de projet	Direction
1. … aux caractéristiques du produit / service / système à livrer	☐	☐	☐	☐
2. … aux méthodes de travail utilisées pour la réalisation du projet	☐	☐	☐	☐
3. … à la composition et aux règles de fonctionnement de l'équipe	☐	☐	☐	☐
4. … aux outils de communication, aux protocoles et aux droits d'accès aux systèmes d'information	☐	☐	☐	☐
5. … aux changements relatifs aux livrables du projet	☐	☐	☐	☐
6. … aux changements relatifs au budget et aux échéanciers	☐	☐	☐	☐
7. … aux relations avec le client	☐	☐	☐	☐
8. … aux relations avec les fournisseurs et sous-traitants	☐	☐	☐	☐
9. … à la gestion des conflits d'équipes	☐	☐	☐	☐

Quelle influence LE CLIENT avait-il sur les choix et les décisions relatifs à…..	TRÈ S PEU d'influence						BEAUCOUP d'influence	Pas en mesu
1.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
2. … aux caractéristiques du produit / service / système à livrer	☐	☐	☐	☐	☐	☐	☐	☐
3. … aux méthodes de travail utilisées pour la réalisation du projet	☐	☐	☐	☐	☐	☐	☐	☐
4. … à la composition et aux règles de fonctionnement de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐
5. … aux outils de communication, aux protocoles et aux droits d'accès aux systèmes	☐	☐	☐	☐	☐	☐	☐	☐
6. … aux changements relatifs aux livrables du projet	☐	☐	☐	☐	☐	☐	☐	☐
7. … aux changements relatifs au budget et aux échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
8. … aux relations avec le client	☐	☐	☐	☐	☐	☐	☐	☐
9. … aux relations avec les fournisseurs et sous-traitants	☐	☐	☐	☐	☐	☐	☐	☐
10. … à la gestion des conflits d'équipes	☐	☐	☐	☐	☐	☐	☐	☐

Quelle influence le RESPONSABLE DE PROJET avait-il sur les choix et les décisions relatifs à…..	TRÈ S PEU d'influence						BEAUCOUP d'influence	Pas en mes
11.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
12. … aux caractéristiques du produit / service / système à livrer	☐	☐	☐	☐	☐	☐	☐	☐
13. … aux méthodes de travail utilisées pour la réalisation du projet	☐	☐	☐	☐	☐	☐	☐	☐
14. … à la composition et aux règles de fonctionnement de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐
15. … aux outils de communication, aux protocoles et aux droits d'accès aux systèmes	☐	☐	☐	☐	☐	☐	☐	☐
16. … aux changements relatifs aux livrables du projet	☐	☐	☐	☐	☐	☐	☐	☐
17. … aux changements relatifs au budget et aux échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
18. … aux relations avec le client	☐	☐	☐	☐	☐	☐	☐	☐
19. … aux relations avec les fournisseurs et sous-traitants	☐	☐	☐	☐	☐	☐	☐	☐
20. … à la gestion des conflits d'équipes	☐	☐	☐	☐	☐	☐	☐	☐

Quelle influence les MEMBRES DE L'ÉQUIPE DISPERSÉE avaient-ils sur les choix et les décisions relatifs à…..	TRÈ S PEU d'influence						BEAUCOUP d'influence	Pas en mesur
	1	2	3	4	5	6	7	
22. … aux caractéristiques du produit / service / système à livrer	☐	☐	☐	☐	☐	☐	☐	☐
23. … aux méthodes de travail utilisées pour la réalisation du projet	☐	☐	☐	☐	☐	☐	☐	☐
24. … à la composition et aux règles de fonctionnement de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐
25. … aux outils de communication, aux protocoles et aux droits d'accès aux systèmes	☐	☐	☐	☐	☐	☐	☐	☐
26. … aux changements relatifs aux livrables du projet	☐	☐	☐	☐	☐	☐	☐	☐
27. … aux changements relatifs au budget et aux échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
28. … aux relations avec le client	☐	☐	☐	☐	☐	☐	☐	☐
29. … aux relations avec les fournisseurs et sous-traitants	☐	☐	☐	☐	☐	☐	☐	☐
30. … à la gestion des conflits d'équipes	☐	☐	☐	☐	☐	☐	☐	☐

Quelle influence la DIRECTION DE VOTRE ORGANISATION avait-elle sur les choix et les décisions relatifs à…..	TRÈ S PEU d'influence						BEAUCOUP d'influence	Pas en mesure de
	1	2	3	4	5	6	7	
32. … aux caractéristiques du produit / service / système à livrer	☐	☐	☐	☐	☐	☐	☐	☐
33. … aux méthodes de travail utilisées pour la réalisation du projet	☐	☐	☐	☐	☐	☐	☐	☐
34. … à la composition et aux règles de fonctionnement de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐
35. … aux outils de communication, aux protocoles et aux droits d'accès aux systèmes	☐	☐	☐	☐	☐	☐	☐	☐
36. … aux changements relatifs aux livrables du projet	☐	☐	☐	☐	☐	☐	☐	☐
37. … aux changements relatifs au budget et aux échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
38. … aux relations avec le client	☐	☐	☐	☐	☐	☐	☐	☐
39. … aux relations avec les fournisseurs et sous-traitants	☐	☐	☐	☐	☐	☐	☐	☐
40. … à la gestion des conflits d'équipes	☐	☐	☐	☐	☐	☐	☐	☐

E – UTILISATION DES OUTILS DE COLLABORATION EN ÉQUIPE DISPERSÉE

Cette section porte sur l'utilisation des technologies de l'information et des communications à des fins de collaboration à distance (*e-collaboration)*. Ces technologies, également appelées « outils de collaboration électronique », permettent l'échange de données et l'interaction entre membres d'une équipe de travail

Les outils suivants furent-ils utilisés entre membres de l'équipe dispersée ?	JAMAIS utilisés						TRÈS SOUVENT utilisés
	1	2	3	4	5	6	7
1. téléphone cellulaire	☐	☐	☐	☐	☐	☐	☐
2. téléphonie par Internet (ex : *Skype*)	☐	☐	☐	☐	☐	☐	☐
3. courriels	☐	☐	☐	☐	☐	☐	☐
4. messagerie instantanée, *chat*	☐	☐	☐	☐	☐	☐	☐
5. forum de discussion	☐	☐	☐	☐	☐	☐	☐
6. outils d'édition (blogues, wiki, etc.)	☐	☐	☐	☐	☐	☐	☐
7. vidéoconférence web	☐	☐	☐	☐	☐	☐	☐
8. agendas électroniques partagés (ex : *Outlook*)	☐	☐	☐	☐	☐	☐	☐
9. collecticiels (ex : *eRoom*, *QuickPlace*, …)	☐	☐	☐	☐	☐	☐	☐
10. site intranet d'entreprise (transfert, partage de documents, etc.)	☐	☐	☐	☐	☐	☐	☐
11. outils de planification et de suivi de projet (ex: *MS-Project, Primavera*, …)	☐	☐	☐	☐	☐	☐	☐
12. outils de gestion de processus (« workflow management system »)	☐	☐	☐	☐	☐	☐	☐
13. outils de gestion de la documentation	☐	☐	☐	☐	☐	☐	☐
14. applications spécialisées de conception collaborative (ex : *CATIA*, …)	☐	☐	☐	☐	☐	☐	☐

Qui avait accès aux technologies suivantes ?	QUELQUES personnes seulement						TOUS les membres de l'équipe
	1	2	3	4	5	6	7
1. téléphone cellulaire	☐	☐	☐	☐	☐	☐	☐
2. téléphonie par Internet (ex : *Skype*)	☐	☐	☐	☐	☐	☐	☐
3. courriels	☐	☐	☐	☐	☐	☐	☐
4. messagerie instantanée, *chat*	☐	☐	☐	☐	☐	☐	☐
5. forum de discussion	☐	☐	☐	☐	☐	☐	☐
6. outils d'édition (blogues, wiki, etc.)	☐	☐	☐	☐	☐	☐	☐
7. vidéoconférence web	☐	☐	☐	☐	☐	☐	☐
8. agendas électroniques partagés (ex : *Outlook*)	☐	☐	☐	☐	☐	☐	☐
9. collecticiels (ex : *eRoom*, *QuickPlace*, …)	☐	☐	☐	☐	☐	☐	☐
10. site intranet d'entreprise (transfert, partage de documents, etc.)	☐	☐	☐	☐	☐	☐	☐
11. outils de planification et de suivi de projet (ex: *MS-Project, Primavera*, …)	☐	☐	☐	☐	☐	☐	☐
12. outils de gestion de processus (« workflow management system »)	☐	☐	☐	☐	☐	☐	☐
13. outils de gestion de la documentation	☐	☐	☐	☐	☐	☐	☐
14. applications spécialisées de conception collaborative (ex : *CATIA*, …)	☐	☐	☐	☐	☐	☐	☐

Quels étaient les autres outils de collaboration électronique utilisés par l'équipe dispersée ?

	BEAUCOUP moins bien équipée			com para ble			BEAUCOUP mieux équipée	Pas en mesure de répondre
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Par rapport à d'autres équipes que vous avez connues, croyez-vous que cette équipe dispersée était bien équipée en outils de collaboration?	☐	☐	☐	☐	☐	☐	☐	☐

D'après vous, quelles sont les lacunes des technologies existantes pour supporter entièrement et efficacement le travail en équipe dispersée

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants?	TOUT À FAIT EN DÉSACCORD						TOUT A FAIT EN ACCORD	Pas en mesure
	1	2	3	4	5	6	7	
Les membres de l'équipe dispersée partageaient bien l'information entre eux	☐	☐	☐	☐	☐	☐	☐	☐
Il y avait un bon esprit d'équipe même parmi les membres éloignés	☐	☐	☐	☐	☐	☐	☐	☐
Les membres utilisaient généralement bien les outils électroniques de collaboration dans le cadre de leur travail.	☐	☐	☐	☐	☐	☐	☐	☐
La confiance régnait parmi les membres de l'équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
Le travail collaboratif à distance convient bien à mon travail	☐	☐	☐	☐	☐	☐	☐	☐

F – PROCESSUS DE PRISE DE DÉCISION

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants ?	Tout à fait EN DÉSACCORD						Tout à fait EN ACCORD	Pas en mesur
	1	2	3	4	5	6	7	
1. Il existait une procédure claire pour déterminer QUI devait participer aux décisions, selon la nature du problème	☐	☐	☐	☐	☐	☐	☐	☐
2. Il existait une procédure claire pour déterminer COMMENT les décisions devaient être prises en équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
3. Avant de prendre une décision importante, les acteurs concernés prenaient le temps de recueillir toute l'information nécessaire	☐	☐	☐	☐	☐	☐	☐	☐
4. Avant de prendre une décision importante, les acteurs concernés prenaient le temps d'évaluer plusieurs options	☐	☐	☐	☐	☐	☐	☐	☐
5. En général, les décisions importantes étaient prises dans un délai normal	☐	☐	☐	☐	☐	☐	☐	☐
6. L'équipe dispersée était solidaire des décisions prises	☐	☐	☐	☐	☐	☐	☐	☐
7. Les décisions importantes furent généralement prises par consensus	☐	☐	☐	☐	☐	☐	☐	☐
8. En général, l'équipe dispersée avait l'autonomie suffisante pour prendre les décisions importantes	☐	☐	☐	☐	☐	☐	☐	☐
9. Les décisions importantes étaient toutes soumises à un mécanisme formel de prise de décision (ex. : *stage gate*, etc.)	☐	☐	☐	☐	☐	☐	☐	☐
10. Une procédure formelle de résolution de problèmes existait pour régler rapidement les difficultés	☐	☐	☐	☐	☐	☐	☐	☐
11. Une fois les décisions prises, elles étaient rarement remises en question	☐	☐	☐	☐	☐	☐		☐
12. La dispersion des acteurs a nui à la rapidité des décisions								☐

Avec quelle efficacité l'équipe dispersée a-t-elle réalisé les activités suivantes?	Équipe TRÈS PEU EFFICACE						Équipe TRÈS EFFICACE	Pas en mesure de
	1	2	3	4	5	6	7	
13. Fixer des objectifs communs	☐	☐	☐	☐	☐	☐	☐	☐
14. Planifier et organiser les tâches à réaliser	☐	☐	☐	☐	☐	☐	☐	☐
15. Tenir des réunions de travail avec les membres dispersés	☐	☐	☐	☐	☐	☐	☐	☐
16. Fournir l'information nécessaire à tous les membres concernés, peu importe leur lieu de travail	☐	☐	☐	☐	☐	☐	☐	☐
17. Effectuer des tâches complexes (ingénierie, programmation, …), à distance, au moyen des technologies de l'information et de communication	☐	☐	☐	☐	☐	☐	☐	☐
18. Échanger des points de vue, résoudre des problèmes et prendre des décisions en équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
19. Résoudre des conflits inter-personnels	☐	☐	☐	☐	☐	☐	☐	☐
20. Faire le suivi et l'évaluation du projet	☐	☐	☐	☐	☐	☐	☐	☐
21. Créer un bon climat de travail	☐	☐	☐	☐	☐	☐	☐	☐

G – LES PRATIQUES DE GESTION DE PROJET

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants ?	Tout à fait EN DÉSACCORD 1	2	3	4	5	6	Tout à fait EN ACCORD 7	Pas en mesu
22. Les membres de l'équipe dispersée avaient toutes les compétences nécessaires	☐	☐	☐	☐	☐	☐	☐	☐
23. Les membres de l'équipe dispersée travaillaient à temps complet sur ce projet	☐	☐	☐	☐	☐	☐	☐	☐
24. Le responsable du projet détenait l'autorité nécessaire pour gérer ce projet	☐	☐	☐	☐	☐	☐	☐	☐
25. Le responsable du projet avait une expérience dans la gestion d'équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
26. Le responsable du projet a clairement assumé son leadership tout au long du projet	☐	☐	☐	☐	☐	☐	☐	☐
27. Les responsabilités des acteurs du projet étaient clairement énoncées et communiquées	☐	☐	☐	☐	☐	☐	☐	☐
28. L'équipe était autonome quant décisions touchant le budget et les échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
29. L'équipe était autonome quant aux décisions touchant le fonctionnement de l'équipe	☐	☐	☐	☐	☐	☐	☐	☐
30. La rémunération des membres de l'équipe tenait compte du contexte dispersé	☐	☐	☐	☐	☐	☐	☐	☐

« La Direction » désigne ici les cadres supérieurs de VOTRE organisation qui vous ont assigné à ce projet.

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants ?	Tout à fait EN DÉSACCORD 1	2	3	4	5	6	Tout à fait EN ACCORD 7	Pas en mesur
31. Au cours du projet, j'avais facilement accès à la Direction de mon organisation	☐	☐	☐	☐	☐	☐	☐	☐
32. Mon organisation m'a fourni une formation adaptée aux équipes dispersées	☐	☐	☐	☐	☐	☐	☐	☐
33. Mon organisation m'a fourni les outils et les méthodes adaptées au travail en équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
34. La Direction de mon organisation a fait un suivi serré du projet	☐	☐	☐	☐	☐	☐	☐	☐
35. La Direction de mon organisation a fait connaître ses attentes vis-à-vis ce projet	☐	☐	☐	☐	☐	☐	☐	☐
36. Les membres de l'équipe dispersée avaient facilement accès aux personnes en autorité chez le client	☐	☐	☐	☐	☐	☐	☐	☐
37. le client a fourni un contexte de travail approprié aux équipes dispersées	☐	☐	☐	☐	☐	☐	☐	☐
38. le client a fourni des outils et des méthodes adaptées au travail en équipe dispersée	☐	☐	☐	☐	☐	☐	☐	☐
39. Le client a fait un bon suivi du projet	☐	☐	☐	☐	☐	☐	☐	☐
40. le client a fait connaître ses attentes vis-à-vis ce projet	☐	☐	☐	☐	☐	☐	☐	☐

H – ÉVALUATION DU PROJET

Dans quelle mesure êtes-vous d'accord avec les énoncés suivants ?	Tout à fait EN DÉSACCORD 1	2	3	4	5	6	Tout à fait EN ACCORD 7	Pas en mesur
1. Le projet a répondu à toutes les exigences techniques spécifiées au départ	☐	☐	☐	☐	☐	☐	☐	☐
2. Tous les livrables prévus ont été remis au client	☐	☐	☐	☐	☐	☐	☐	☐
3. Le(s) client(s) se sont montrés satisfaits	☐	☐	☐	☐	☐	☐	☐	☐
4. Les échéanciers initiaux ont été respectés	☐	☐	☐	☐	☐	☐	☐	☐
5. Le budget a été respecté à l'intérieur d'une marge raisonnable (+/-15%)	☐	☐	☐	☐	☐	☐	☐	☐
6. Ce projet a permis d'accroître l'expertise au sein de mon organisation	☐	☐	☐	☐	☐	☐	☐	☐
7. Je serais prêt à re-travailler avec la même équipe sur un autre projet	☐	☐	☐	☐	☐	☐	☐	☐

Le fait de travailler en ÉQUIPE DISPERSÉE a-t-il eu un impact particulier sur…	Effet TRÈS NÉGATIF 1	2	3	Aucun effet 4	5	6	Effet TRÈS POSITIF 7	Pas en mesur
1. …la qualité des livrables	☐	☐	☐	☐	☐	☐	☐	☐
2. …le respect du budget	☐	☐	☐	☐	☐	☐	☐	☐
3. …le respect des échéanciers	☐	☐	☐	☐	☐	☐	☐	☐
4. …la satisfaction du client	☐	☐	☐	☐	☐	☐	☐	☐

I – INFORMATION SUR VOTRE ORGANISATION

Si vous travaillez pour une grande entreprise, répondez à ces questions en considérant l'unité administrative (division, filiale, succursale, etc.) directement concernée par ce projet et pour laquelle vous avez suffisamment de connaissances. Considérez alors cette unité administrative comme votre « organisation ».

1. Est-ce que votre organisation est une entreprise privée ? Oui Non

   Si oui, quel est le chiffre d'affaires annuel brut de votre organisation : $CDN

   2.a) Quel est le pourcentage des ventes réalisées au Canada? %
   2.b) Quel est le pourcentage des ventes réalisées aux États-Unis? %
   2.c) Quel est le pourcentage des ventes réalisées dans le reste du monde ? %

2. Combien d'employés (temps complet) y a-t-il dans votre organisation?

3. Parmi les secteurs suivants (classification de Statistique Canada), lesquels décrivent le mieux votre organisation?

☐ SCIAN 22 Services Publics (électricité, gaz et eau)
☐ SCIAN 23 Construction
☐ SCIAN 31-33 Fabrication
☐ SCIAN 41-45 Commerce de gros ou de détail
☐ SCIAN 52 Finance et assurances
☐ SCIAN 54 Services professionnels, scientifiques et tech
☐ SCIAN 62 Soins de santé et assistance sociale
☐ SCIAN 71 Arts, spectacles et loisirs
☐ SCIAN 91 Administrations publiques
☐ Autre (spécifiez)

4. Est-ce que votre organisation détient une certification relative aux processus d'affaires (ISO, CMMI, HACCP, etc.)

☐ Non
☐ Si oui, laquelle / lesquelles?
☐ Je ne sais pas

Sur la base de votre expérience, nommez trois ingrédients essentiels à la réussite des projets lorsque l'équipe est dispersée ?

MERCI DE VOTRE COLLABORATION !

Pour tout renseignement relatif à ce questionnaire, veuillez communiquer avec l'un des chercheurs suivants :

Mario Bourgault	Ecole Polytechnique	if 514-340-4711, poste 5956	Q mario.bourgault@polymtl.ca
Nathalie Drouin	UQAM	if 514-987-3000, poste 3463	Q drouin.nathalie@uqam.ca