Educating supply chain professionals to work in global virtual teams

Shardul Phadnis
Postdoctoral Associate, Center for Transportation & Logistics
Massachusetts Institute of Technology
77 Massachusetts Ave E40-286, Cambridge, MA 02139
shardul@mit.edu
Phone: 617.258.8786; Fax: 617.253.4560

Roberto Perez-Franco
Research Associate, Center for Transportation & Logistics
Director, Supply Chain 2020 Project
Massachusetts Institute of Technology
77 Massachusetts Ave E40-293, Cambridge, MA 02139
roberto@mit.edu
Phone: 617.253.7036; Fax: 617.253.4560

Chris Caplice
Executive Director, Center for Transportation & Logistics
Massachusetts Institute of Technology
77 Massachusetts Ave E40-275, Cambridge, MA 02139
caplice@mit.edu
Phone: 617.258.7975; Fax: 617.253.4560

Yossi Sheffi
Elisha Gray II Professor of Engineering Systems
Professor of Civil and Environmental Engineering
Massachusetts Institute of Technology
77 Massachusetts Ave E40-261A, Cambridge, MA 02139
sheffi@mit.edu
Phone: 617.253.5316; Fax: 617.253.4560

Educating supply chain professionals to work in global virtual teams

What factors influence the performance of global virtual teams? We test the answer this question using a supply chain simulation game played online by 20 teams of graduate students in the MIT SCALE network. Each team consisted of four to five students located each on four continents (North America, South America, Europe, and Asia), who had not met each other before. We examine how nine characteristics of teamwork, eleven demographic and personality attributes of individual team members, and various methods of communication influence the performance of such global virtual teams. Our results show that this performance is a function of individual ability (analytical reasoning, overall intellectual competence) as well as trust among the team members. Surprisingly, several characteristics of individuals (e.g. work experience, age, gender) and teams (clear direction, learning behavior, etc.) do not explain variation in the teams' performance. All nine teamwork characteristics also exhibit a strikingly similar pattern of change over the duration of the study.

1 Introduction

It is exceptionally rare to find a modern firm that sources, manufactures, and distributes all within the same country, continent, or even hemisphere. Supply chains today are global by design and therefore there is a need for global teams to coordinate with each other. In many cases, this means that the team members need to work on a project having never met face to face before. In a recent survey of its members (2012), the Society for Human Resource Management (SHRM, 2012) found that 46% of the organizations polled were using virtual teams[1]. While two out of three multinational firms used virtual teams, 28% of the firms with U.S.-based operations were relying on virtual teams as well. Respondents of same survey rated "building team relations" as the single biggest factor that could affect a team's success. Given the prevalence of global virtual teams and the likelihood of the increase in their use, it is useful to know what factors affect their performance. Furthermore, it is also important that the future supply chain professionals be trained to work effectively in global virtual teams. The MIT Global Supply Chain and Logistics Excellence (SCALE) Network was designed to provide the experience of working in global virtual teams to its students.

In this paper, we first feature the MIT SCALE Network and describe its recent "active learning" initiative to train supply chain professionals to work in and manage global virtual teams. Following this, we present the preliminary results of the research conducted to understand the workings of global virtual teams and what factors affect their performance. This research has been conducted using a four month long online supply chain simulation game played by 20 global virtual teams of 98 students in the four Masters' programs offered by the SCALE network.

The rest of this document is structured as follows. Section 2 overviews the pertinent findings from the literature on teams and global virtual teams. Section 3 describes the MIT SCALE network and the supply chain simulation game played by the 20 student teams. Section 4 describes the research method and presents the preliminary results. Finally, section 5 summarizes the findings.

2 Literature

In the introduction to an Organization Science special issue on virtual teams, DeSanctis and Monge (1999) defined a virtual team as a "collection of geographically distributed, functionally and/or

[1] SHRM defined virtual teams as the "groups of individuals who work across time, space and organizational boundaries and who interact primarily through electronic communications."

culturally diverse entities that are linked by electronic forms of communication and rely on lateral, dynamic relationships for coordination." Global virtual team members are located in different countries and possibly belong to different cultures. Such a virtual team structure allows an organization or a group of organizations the freedom to "dynamically modify business processes to meet market demands, to coordinate via formal and informal contracts, to define boundaries of the firm differently over time or for different customers or constituencies, and to rearrange relationships among constituencies as needed" (ibid). This ability to dynamically organize expertise, skills, cultural knowhow, etc. residing in a global organization to address the peculiar needs of its customers in different parts of the world is an invaluable asset to the organization. However, to take advantage of this potential, organizational managers need to know how to assemble and manage the global teams.

While global virtual team is a relatively new phenomenon, work groups have been around and studied since the 1920s, starting notably with the Hawthorne studies (Mayo, 1933). The earlier studies sought to understand the effect of organization design of the workgroup productivity. Recent research has focused on understanding how workgroup or team characteristics themselves relate to the team's performance (Campion, Medsker, & Higgs, 1993). Research shows that while team structural characteristics (such as job design, task and process interdependence) explain the variation in a team's productivity, the stronger predictors of team performance are related to the team's work process itself. The team "process" characteristics include belief in the team's efficacy (analogous to "team spirit"), work sharing, support for the team members, and communication and cooperation. The relationship of team efficacy with the team's performance is mediated by the team's learning behavior, which is positively associated with team's performance. Learning behavior is also shown to be positively related to "psychological safety", i.e. a shared belief among the team members that the team is safe for interpersonal risk-taking (Edmondson, 1999). Ultimately, team efficacy and psychological safety are both influenced by a structural feature: team leader coaching. Thus, effectively the leader of a team can indirectly affect the team's productivity by influencing the members' belief in the team's efficacy and the way team members engage and interact in the team.

Do these findings generalize to virtual teams? Akin to the traditional teams, members of the global virtual teams are also held together through a common identity, customers, and other constituents (DeSanctis & Monge, 1999). However, they do not possess knowledge of their distant team members. The direct knowledge of the distant teammates' as well as the knowledge of one's own site reflected through the interaction with the distant colleagues are both important for fostering trust in the team (Mortensen & Neeley, 2013). A form of "swift trust", which develops among team members—such as film crews, cockpit crews, theater groups, etc.–with a limited history and future prospect of working together (Meyerson, Weick, & Kramer, 1996), was also reported in about half (15 out of 29) of the global virtual teams studied by Jarvenpaa and Leidner (1999). Over time, four other teams managed to develop a high level of trust, but trust levels dropped in five of the 15 teams that initially had reported high levels of trust. Thus, the limited empirical evidence suggests a rather fragile nature of trust in global virtual teams. Given the importance of trust and other team process attributes to team performance and given that lasting trust may not develop in virtual teams on its own, it is important that supply chain professionals, who are likely to engage in and manage global virtual teams, be educated to work effectively in such teams.

3 Learning to work in global virtual teams at MIT Global SCALE Network

Global virtual teams are increasingly used in business today. Unfortunately, there is very little research on or training for supply chain professionals working on such teams. Most academic programs are either in-residence (where students are collocated and interact primarily face-to-face)

or individual based on-line (where students do not interact with anyone). The MIT Global Supply Chain and Logistics Excellence (SCALE) Network was designed to fill this educational gap.

3.1 MIT Global SCALE Network

The MIT Global SCALE Network (2013) is an international alliance of research and education centers. Each center is dedicated to the development and dissemination of innovation in supply chain and logistics. At the time of this study, the network consisted of four centers on four continents: North America (Cambridge, MA), South America (Bogota, Colombia), Europe (Zaragoza, Spain) and Asia (Kuala Lumpur, Malaysia). Each center has its own faculty and research staff, and administers its own graduate program in Supply Chain Management.

While the centers are technically independent, they are strongly connected to each other through administrative, research, and educational ties. The centers coordinate all admissions, marketing, and corporate outreach activities in order to leverage the size and scope of the network. Similarly, research projects are jointly run across the centers to both leverage the faculty, but also to gain a global perspective. For example, a recent study examining cultural or geographic differences in risk profiles for supply chain professionals across the globe was jointly run across the four centers and ultimately collected data from 70 different countries (Arntzen, 2011). The four centers are most aligned on their educational programs, particularly the 10-month graduate supply chain management programs.

Students for the four programs tend to come from the same international pool of prospective supply chain professionals aged 26 to 34. The only exception is the South America center (Center for Latin-American Logistics Innovation), which draws solely from countries in that continent. The 2013 SCALE class consisted of 98 students from 49 countries and five continents. The SCALE curriculum is harmonized across the centers and consists of four phases: Orientation (a 3-4 week period of re-introduction to academics), Fall (semester long focus on fundamentals in analysis, leadership, and technology), January (a month long exposure to practice to include global treks, simulations, tours, and special topics), and finally, Spring (with a focus on strategy and where students complete their thesis projects with their corporate partners).

Classes at all of the centers during the Orientation, and Fall and Spring semesters are generally taught using "active learning" techniques (Meyers & Jones, 1992). The Case Study method initiated and used at Harvard Business School and the Beer Distribution Game (Sterman, 1989) developed at MIT are two of the most prominent examples of use of active learning in management programs. The SCALE Network is a strong proponent of the idea that students mainly learn from applying concepts to real problems and receiving immediate feedback from faculty as well as peers. Active learning with rapid feedback seems to work exceptionally well with older students who have been working for several years (Malcolm S. Knowles and Associates, 1984). While the students spend the majority of their time working with their local cohort and being taught by their local faculty, the SCALE Network adds a unique dimension to the curriculum. To complement the course work during semesters, the MIT Independent Activities Period in January provides opportunities for active learning outside the classroom. During this time all students spend almost a month at MIT, conducting joint exercises and tours, present their mid-phase reviews of their thesis projects to corporate sponsors, and trek to different logistics hubs of their choice. In 2013 the students trekked to the Panama Canal, Zaragoza, and China.

The experience of working on a Global Virtual Team became part of the curriculums for the first time in the 2012/2013 academic year. Starting in the Fall semester, the students were introduced to their peers at the other centers through joint "all-hands" web-meetings. During this meeting they were informed of the SCALE Challenge – a four-month competitive virtual team-based supply chain simulation (the simulation itself is discussed in detail in §3.2.1). The idea behind

this simulation is to *expose the SCALE students to challenges involved in working in a global virtual team using active learning* rather than just talking about it. The students were randomly assigned to 4-5 person network-wide teams, where each team was comprised of members from four different centers; there were no "all-local" teams. The students were told that they needed to submit their first assignment within a day or two. By doing this so abruptly, we tried to replicate the nature of global supply chain management, where teams of professionals must form teams quickly even having never met. The simulation lasted for four months between October and January, and is explained in detail in §3.2.2.

3.2 2013 SCALE Challenge

The 2013 SCALE Challenge was a supply chain management game played with the 98 students of the 2013 cohort of the MIT Global SCALE Network program. The Challenge made use of a web-based supply chain simulation known commercially as The Fresh Connection (TFC). The next two sections review the TFC simulation and elaborate on how it was used in the SCALE Challenge.

3.2.1 The Fresh Connection

The Fresh Connection (TFC) is a simulation game developed to train students and practitioners in concepts of supply chain management. It revolves around a fictitious company in the fruit juice industry, which – at the start of the game – has a negative return on investment (ROI) of about 8%. The objective of the game is to maximize the ROI. The business model of TFC Company is relatively simple: it procures fruit and ingredients from a few chosen suppliers, produces and bottles the juice in its own facilities, and ships the finished product to up to three customers: a gas station convenience store, a supermarket chain, and a bulk store chain.

The simulation has four functional roles: Production, Sales, Procurement and Supply Chain. The person in charge of each functional role is required to make decisions regarding multiple variables that affect its function and the company as a whole. Thus, for example, Procurement will negotiate agreements with suppliers, Production will decide on warehousing capacity, Sales will negotiate agreements with customers and Supply Chain will decide on inventory levels. A fifth role—CEO—with no decision power over any particular set of variables can be added. All team members have visibility to the decisions of all other roles and the outcomes, however the person in charge of a function can change the decisions related to only his/her function. Exhibit 1 shows the software interface for entering Supply Chain decisions; other functions have similar interfaces. After entering the decision values for each function, the simulation translates all performance metrics of the company—such as customer service level, product quality and environmental footprint, etc.—to monetary terms that impact a single metric: the ROI. Exhibit 2 depicts the results interface. A team can obtain details for each line on the ROI statement by clicking the "+" sign next to that line.

The game is played in rounds, with each player taking responsibility for one function. Every simulation round is equivalent to six months of operations for the firm. Team members are provided the results of each simulation run and are encouraged to deliberate their decisions in each round. Even though multiple teams can play the game simultaneously, there is no interaction among the teams. Any competition among them takes place outside of the simulation, by merely comparing their respective ROIs. The overall progression of the TFC simulation game is presented using a flowchart in Exhibit 3.

The supply chain of the TFC Company is relatively simple, yet not simplistic; some teams fail to achieve a positive ROI even after multiple rounds. It presents many of the challenges that an actual supply chain presents: making interrelated decisions affecting sections of a dynamic, complex system under imperfect information. We used this simulation in a Masters-level program, and think it will be a good tool for teaching the interdependence among supply chain decisions to students in

MBA or other graduate programs. To be useful as an educational tool, instructors need to conduct multiple rounds of the simulation with their students and provide feedback after each round.

3.2.2 The SCALE Challenge

The 2013 SCALE Challenge was a four month long supply chain simulation exercise – conducted between September 2012 and January 2013 – that included all 98 students from the four masters-level programs within the SCALE Network. The students were arranged into 20 teams of five members each (with two teams having only 4 members). 16 out of 20 teams had at least one member from each of the four SCALE centers; the remaining four had students from three centers. Table 1 shows the composition of the 20 teams.

The students played 12 rounds of the simulation game. The first six rounds were played remotely by the students from their respective locations: Massachusetts, Malaysia, Spain and Latin America - without having ever met physically with their team members. The last six rounds were played when all the students convened at MIT (Cambridge) during January 2013. The rounds were designed in a particular sequence to expose the students to increasing levels of difficulty while covering ever more complex supply chain subjects. From seven levels of difficulty available in TFC software, levels three through seven were used. Each level was used at least twice. Each pair of rounds had a theme associated to it.

- Rounds 1 and 2 were played at Level 3. The theme was the importance of formulating a coherent strategy for the supply chain.
- Rounds 3 and 4 (Level 4) emphasized the importance of sequencing decisions through S&OP.
- Rounds 5 and 6 (Level 5) emphasized sustainability in supply chains by including penalties and rewards for compliance with carbon emissions commitments.
- Rounds 7 and 8 (Level 6) emphasized collaboration with suppliers and customers.
- Rounds 9 and 10 (Level 6) emphasized preparation for unpredictable disruptions.
- Rounds 11 and 12 (Level 7) offered the possibility of collaborating with other companies to obtain better prices on technology or raw materials. These rounds were played in a large room with all the teams present.

After each round, the students were given the results of the simulation for their team, the ROI of the best five teams and the relative ranking of the twenty teams. After the sixth round, the students were also given a more detailed report of their team's performance compared to that of the leading and average teams, along two dozen relevant variables that impact ROI.

The students were informed that all members of the winning team would get a prize. Prizes were also given to the teams that showed the largest improvement in relative ranking or average ROI recovery to incentivize all teams – and not just the top performers – to stay engaged in the competition. Even though the students were reminded throughout the Challenge that the whole thing was "just a game" many teams were passionate about competing and cheered or jeered when the results were announced.

4 Teamwork in global virtual teams and performance: Method

The objective of the research was to examine the performance of global virtual teams and the factors that affect the teams' performance. To this end, the students playing the game were surveyed four times to gather information about their teamwork. The surveys were conducted after rounds 2, 4, 6, and 7. Thus, the students completed three surveys before meeting their teammates in person and one survey after. Each survey was administered using an online survey tool, and conducted *after*

the teams entered their decisions for the round and *before* they were informed of their performance in that round.

4.1 Variables

The surveys asked questions regarding four aspects of the collaboration: characteristics of teamwork (nine constructs), team engagement (two), communication methods (two), and approach to decision-making (one). The teamwork constructs were selected from Edmondson's (1999) work on learning behavior in work teams, which compiles previous set of teamwork constructs and introduces a new construct (psychological safety) shown to affect team performance. Nine out of 11 constructs from Edmondson's work were tested in the survey; the two not tested were "team monitoring" and "team performance". The former was omitted as it was found to be less relevant for a global virtual team, the latter was omitted because an objective measure was used to measure team performance – team ROI – obviating the need for the team's perception of their performance. The complete list of teamwork constructs and the relevant survey items is presented in Table 2. The remaining variables were used to capture the methods used to communicate and make decisions by the team. The survey items for the remaining constructs are presented in Table 3. In addition to the predictors mentioned above, eight demographic variables were collected for each student: gender, age, country of origin, MBTI profile, work experience, GRE/GMAT scores, Masters' program registered in, and rank in the program.

4.2 Results from the teamwork surveys

The preliminary results of the teamwork surveys are presented in four sections. We first examine how the nine teamwork constructs vary over time before and after the team members meet in person (§4.2.1). Following this, we seek to identify the factors that can explain the variation in team performance. For that, we first examine what attributes of the individual team members as well as the characteristics of the team influencing the team's performance (§4.2.2). Next, we study whether team performance varies by the methods of collaboration used by the team members (§4.2.3). Finally, we evaluate the variation in all nine teamwork attributes by the demographic characteristics of the students (§4.2.4).

4.2.1 Evaluation of teamwork by virtual and real teammates over time

An interesting question is to understand how various teamwork characteristics of a global virtual team change over time – especially before and after the meet in person. In this study, all nine teamwork constructs exhibited an identical pattern over the duration of the study, as presented in Exhibit 4. The constructs deteriorated from survey I through III (conducted after game rounds 2, 4, and 6) as the students worked remotely in the global virtual teams for three months. However, the performance exhibited a sharp jump after the team members met in person (survey IV; conducted after game round 7)[2]. Interestingly, the deterioration in none of the teamwork constructs from survey I through III was significant at $p \leq .05$, either per Welch's t-test (Exhibit 5) or the paired t-test (Exhibit 6). Barring the assessments of "Team Efficacy" and "Team Learning Behavior", improvements in all other teamwork constructs after the face-to-face meeting were significant at $p \leq .05$ or better (see paired t-test, Exhibit 6).

4.2.2 Team performance as a function of individual attributes and team characteristics

Another interesting question is to know which aspects of teamwork have strong relationships with the team's performance. We measured team performance using team's ROI in the most recent

[2] The number of students completing the questionnaires, which were deliberately kept non-mandatory, dropped throughout from survey I through IV (91, 88, 76, and 68 completions, respectively).

round of the simulation game before the survey was administered. Exhibit 4 shows the correlation between team ROI, team rank, and the evaluation of nine teamwork constructs by individual members from the data collected from all four surveys. Correlations based on the data from the first three surveys, when the teams were working as virtual global teams, are very similar to those presented in Exhibit 4. Since team's rank is calculated using the ROI, a strong correlation (– 0.91) between the two is observed, as expected. Of the nine teamwork constructs "Team Trust" has the strongest correlation with team performance ($\rho = 0.30; 95\%\ \text{range}\ 0.19 - 0.40$). The next three strongest correlates are "Team Efficacy" ($\rho = 0.23; 0.12 - 0.34$), Psychological Safety" " ($\rho = 0.22; 0.12 - 0.33$), and "Team Composition" ($\rho = 0.22; 0.11 - 0.32$). Correlations calculated at the team-level show identical patterns to those at the individual-level, except their coefficients are higher and have wider confidence intervals due to 3-to-4 fold decrease in sample size.

The multiple regression analysis of data from all four surveys (Exhibit 8) shows that among nine team characteristics, "Intra-team Trust" is the only statistically significant predictor of team performance (Models 1, 3). Among individual attributes, the students' "GMAT-Analytical score" and "Class rank" appear as significant predictors of how their team performs (Models 2, 3). Surprisingly, class rank makes a positive contribution to the team's performance (lower class rank is indicative of better class performance, 1 being the best). Since the data about individual attributes is still being collected, only 120 observations available for Models 2 and 3 compared to the full set of 307 observations available for Model 1, where the predictors are only the nine team characteristics. Thus, the results of regression analysis for individual attributes may change after the dataset is complete. The models developed using data collected in the first three surveys are similar to the models developed with data from all four surveys. The only exception is that "Age" shows up as a significant predictor of team performance in Model 2, but disappears in Model 3.

Due to the high correlations among all attributes of teamwork, the multiple regression models suffer from multicollinearity. While it affects the coefficients of individual predictors, multicollinearity does not affect the overall predictive power of the model. In general, the results (Model 3) using both datasets show that *individual analytical reasoning capability*, *class performance*, and *intra-team trust* can explain 21-to-23% of the variation in performance of global virtual teams.

4.2.3 Team performance as a function of methods of collaboration

Do methods of collaboration used by the global virtual teams relate to team performance? Two aspects of team collaboration are evaluated vis-à-vis their effect on team performance: use of various communication methods, and team meeting times and attendance. Exhibit 9 presents the results of ANOVA of team performance with the use of communication methods by the global virtual teams. This analysis is based on the data collected in the first three surveys only, when the students were working in virtual teams and had not met in person yet. The results show that only the variation in the use of "Phone Calls" (whether used) can explain only a small portion (2.8%) of the variation in team performance at $p < 0.5$. Exhibit 10 presents the results of ANOVA of team performance and team engagement (team meeting times and number of participants in a typical meeting) for the global virtual teams (data taken from the first three surveys). The results show that the variation in team performance cannot be explained by the duration of or attendance in a typical meeting.

4.2.4 Teamwork constructs and demographic variables

Finally, we explore whether the evaluation of various teamwork constructs is influenced by demographic characteristics. Five demographic characteristics were considered for this analysis: age, gender, program, region of origin, and Myers-Briggs Type Indicator (MBTI) personality profile. While the data about age, gender, program, and country of origin was available for all 98 students, MBTI results were shared by only 59 students. Therefore, the analysis of variance between MBTI

and the teamwork characteristics was performed separately from the rest of the demographic variables, so larger sample size could be used for the latter.

The results of analysis of variance in nine teamwork constructs are summarized in Exhibit 11. Out of the 36 possible relationships (between 9 teamwork constructs and 4 demographic variables: age, gender, program, and origin), in only three instances the variation in a teamwork attribute can be explained by the variation in a demographic variable at $p < 0.05$ as follows:

- Graduate programs where the students were registered explained 2.8% of the variation in evaluation of whether the team had a "Clear Direction". Students from the Asian center evaluated their teams higher for having a "Clear Direction" compared to their colleagues in the European center.
- Variation in graduate program also explained 3.3% of the variation in "Team Effort". Students in the European center evaluated their team's effort to be significantly lower compared the students in the South American center.
- Variation in "Origin (Region)" explained 4.8% of the variation in "Psychological Safety". Students from South & East Asia expressed lower levels of "Psychological Safety" in their teams compared to their colleagues in South and Central America.

In addition, variation in "Origin (Region)" was also able to explain 3.8% of the variation in "Team Composition", but at a weaker level of significance ($p < 0.1$): team composition was assessed to be stronger by students from South America than those from North America and South & East Asia.

The results of analysis of variance in nine teamwork constructs by the MBTI personality characteristics are summarized in Exhibit 12. The 59 students who shared their MBTI profiles include 32 Extroverts and 27 Introverts; 27 Intuitive and 32 Sensing perceivers; 13 Feeling and 46 Thinking judges; and 35 Judging and 24 Perceiving individuals. The ANOVA of each teamwork characteristics against the four MBTI attributes shows no effect of any MBTI characteristic on the assessment of teamwork at $p < 0.05$. For three teamwork characteristics—Psychological Safety, Team Composition, and Team Efficacy—the average evaluations by Extroverted individuals are higher than the Introverted individuals at $p < 0.10$.

5 Summary

Firms are increasingly relying on Global Virtual Teams as their operations and supply chains have stretched across the globe. It is necessary to understand what factors affect the performance of such teams. Furthermore, it is also important to train supply chain professionals to work in and manage such teams effectively. This paper highlights the initiatives of the MIT Global SCALE Network to impart this training to the graduate students in its four supply chain programs, and presents some preliminary results describing how global virtual teams operate.

Our results show that global virtual teams exhibit a pattern of a small but steady (although not statistically significant) deterioration in nine team characteristics during their engagement. This drop demonstrates the fragile nature of team trust and other characteristics observed in global virtual teams by previous researchers (Jarvenpaa & Leidner, 1999). All nine team characteristics also experienced a sharp improvement after the team members met face-to-face. This improvement provides empirical support to the findings that first-hand experience is of paramount importance in bridging the interpersonal gap (Hinds & Kiesler, 2002). Our finding – that the quality of teamwork as perceived by members of global virtual teams is inferior to the co-located teams and that quality is likely to deteriorate over the duration of the project – underscores the need for educating the supply chain professionals to develop necessary skills for working and managing such global virtual teams. Interestingly, our results provide empirical support to the Yahoo! CEO Marissa Mayer's decision to end the company's work-from-home arrangements a month after our study concluded (WSJ, 2013).

Our preliminary analysis reveals that the team characteristic of utmost importance for team performance is intra-team trust. The trust alone was able to explain 8-to-9% of the difference in performance. Trust among team members could help build a "high common ground" in the team, which is considered essential for remote teams to succeed (Olson & Olson, 2000). The ability of the individual team members, namely the analytical reasoning skills and overall intellectual competence (as measured by class rank), also attribute to team performance. However, other individual characteristics – such as gender, quantitative or verbal skills, or work experience – do not appear to cause variation in performance, at least in the type of challenge tackled by the teams in our study. Our results do not show performance variation from the use of different communication methods, except for a small variation related to the use of phone calls. However, this could be the result of rather low variation in the use of different communication methods in our study. Similarly, the duration of team meeting or participation in meetings do not show any effect on team performance.

Another interesting preliminary finding of the study is that the variation in a few teamwork characteristics is related to the region team members come from. Extant research suggests that birthplace dissimilarity is related to trust in virtual teams (Krebs, Hobman, & Bordia, 2006). Our data indicates that members of global virtual teams coming from different parts of the world may assess different aspects of their team differently. Whether this has any implications for team performance remains to be studied.

In conclusion, we want to emphasize that global virtual team is an important object of study for the supply chain management profession, and supply chain researchers need to uncover what factors affect the performance of such teams. Furthermore, it is also important that future supply chain professionals are trained to work in and manage global virtual teams. We illustrate one such active learning initiative undertaken by the MIT Global SCALE Network to meet this end.

6 Bibliography

SHRM. (2012, Jul 19). Retrieved Feb 13, 2013, from Society for Human Resource Management: http://www.shrm.org/hrdisciplines/orgempdev/articles/Pages/VirtualTeamsUsedMostbyGlobalOrganizations,SurveySays.aspx

Arntzen, B. (2011). *Global supply chain risk management Part 1: Differences in attitudes*. Cambridge, MA: MIT Center for Transportation & Logistics.

Campion, M. A., Medsker, G. J., & Higgs, A. C. (1993). Relations between work group characteristics and effectiveness: Implications for designing effective work groups. *Personal Psychology, 46*, 823-850.

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

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly, 44*(2), 350-383.

Hinds, P. J., & Kiesler, S. (2002). *Distributed work*. Cambridge, MA: MIT Press.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and trust in global virtual teams. *Organization Science, 10*(6), 791-815.

Krebs, S. A., Hobman, E. V., & Bordia, P. (2006). Virtual teams and group member dissimilarity. *Small Group Research, 37*(6), 721-741.

Malcolm S. Knowles and Associates. (1984). *Andragogy in action: Applying modern principles of adult learning*. San Francisco, CA: Jossey-Bass Publishers.

Mayo, E. (1933). *The human problems of an industrial civilization*. New York: The Macmillan Company.

Meyers, C., & Jones, T. B. (1992). *Promoting active learning: Strategies for the college classroom*. San Francisco, CA: Jossey-Bass, Inc.

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In R. M. Kramer, & T. R. Tyler (Eds.), *Trust in Organizations: Frontiers of Theory and Research* (pp. 166-195). Thousand Oaks, CA: Sage Publications.

MIT Global SCALE Network. (2013). *About Us.* Retrieved Feb 19, 2013, from http://ctl.mit.edu/about_us/global_scale_network

Mortensen, M., & Neeley, T. B. (2013). Reflected knowledge and trust in global collaboration. *Management Science.*

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction, 15*, 139-178.

Sterman, J. D. (1989). Modeling managerial behavior: Misperceptions of feedback in a dynamic decision making experiment. *Management Science, 35*(3), 321–339.

WSJ. (2013, Feb 26). *The home office in the spotlight.* Retrieved from The Wall Street Journal: http://online.wsj.com/article/SB10001424127887323384604578328681101539330.html

Tables

Team Name	Asia	Europe	North America	South America
Awesome Penta	1	1	2	1
Dralz	-	1	2	2
Fructus Vinculum	1	1	2	1
Global Oranges	1	1	2	1
Interlog	1	1	2	1
Jambo Kings	1	1	2	1
MAYA	1	1	1	2
MIC3	-	1	2	2
Naranja	1	1	2	1
P+	-	1	2	2
Pangaea	1	1	2	1
Red Hot Supply Chain Peppers	1	1	2	1
RICOTECH	1	1	2	1
SC Uno	1	1	1	2
SCalers	1	1	1	1
Solar Solutions	1	1	2	1
Supply Chain Masters Inc.	1	1	2	1
The Solvers	1	1	2	1
The Unscaleables	-	1	2	2
VooDoo Masters of Supply Chain	1	-	2	1
Total number of students	**16**	**19**	**37**	**26**

Table 1: Teams and number of students from each SCALE center

Clear Direction

- This team spent time making sure every team member understands the team objectives
- This team spent time making sure every team member understands his/her role
- This team spent time making sure every team member understands how the decisions for his/her role affect the team objectives

Team Composition

- Most people in this team have the ability to solve the problems that come up in our work
- Certain individuals in this team lack the special skills needed for good team work

Intra-team Trust

- I can rely on my team members to keep their word.
- I trust my team members.
- I need to double-check my team member(s)' work

Team Efficacy

- Achieving this team's goal (winning the game) is well within our reach
- This team can achieve its task without requiring us to put in unreasonable time or effort
- With focus and effort, this team can do anything we set out to accomplish

Team Psychological Safety

- If you make a mistake on this team, it is held against you
- Members of this team are able to bring up problems and tough issues
- People of this team sometimes reject others for being different
- It is safe to take a risk on this team
- It is difficult to ask other members of this team for help
- Working with members of this team, my unique skills and talents are valued and utilized

Team Learning Behavior

- This team tends to handle differences of opinion privately or off-line, rather than addressing them directly as a group
- In this team, someone always makes sure that we stop to reflect on the team's work process
- People in this team often speak up to test assumptions about issues under discussion

Team Reflexivity

- In this team we often discuss the methods used to get to the job done
- In this team we regularly discuss whether we are working effectively together
- In our team we often review our approach to getting the job done

Team effort

- Even when experiencing setbacks, team members try to the best of their ability to realize team goals
- Most team members go out of their way to accomplish team objectives, even when others are taking it easy

Team execution

- Everyone in this team has a say about the final decision in each role
- On this team the individual assigned to a specific role has the final say on decisions within their responsibility
- One or a few members of this team dictate their will on the team when making the final decision

Table 2: Teamwork Constructs and Survey Items

Communication methods (Frequency of use): Choose one from the following for each communication methods in {Chat, Emails, Phone calls, Skype (Audio), Skype (Audio + Video), Social networks, Text messaging, Twitter, Other, In-person (only for Survey IV)}

- None
- Once
- Twice
- 3-5 times
- 6 or more times

Communication methods (Value): Value of each communication method above. Choose one from:

- Exceptionally high
- High
- Moderate
- No value

Team engagement (Duration of a typical team meeting): Choose one from:

- We never met
- Less than 15 minutes
- 15-30 minutes
- 30 minutes to 1 hour
- More than 1 hour

Team engagement (Attendance at a typical team meeting): Choose one from:

- We did not have team meetings
- Most team meeting were attended by at most 2 members
- Most team meetings were attended by minimum 3, but not all, members
- Most team meetings were attended by all members
- All team meetings were attended by all members

Team's decision-making approach: Choose one from:

- *Reacted*: Made ad-hoc decisions, with no connection to the business strategy and no specific sequence
- *Anticipated*: Each functional role made separate decisions in its own silo, with little or no connection to the business strategy
- *Collaborated*: Made joint decisions following a rough logical sequence, giving trade-offs some consideration, in line with the business strategy
- *Orchestrated*: Used a formalized logical sequence for joint decision making based on business strategy; individual roles prepared considering the trade-offs beforehand

Table 3: Survey items about communication methods, meetings, and decision-making approach

Exhibits

Exhibit 1: Fresh Connection: Supply Chain Management decision interface

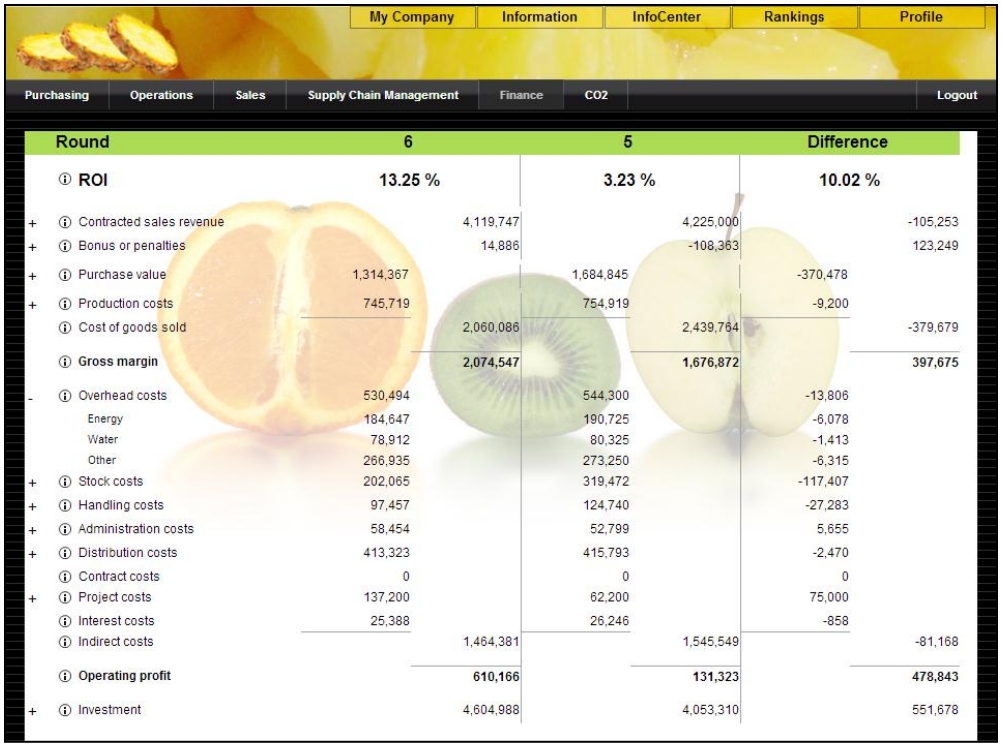


Exhibit 2: The Fresh Connection interface (Team performance results)

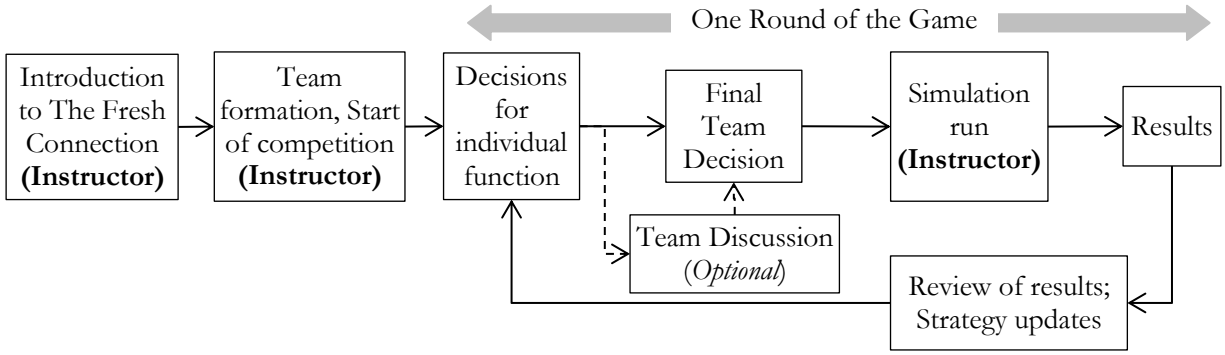
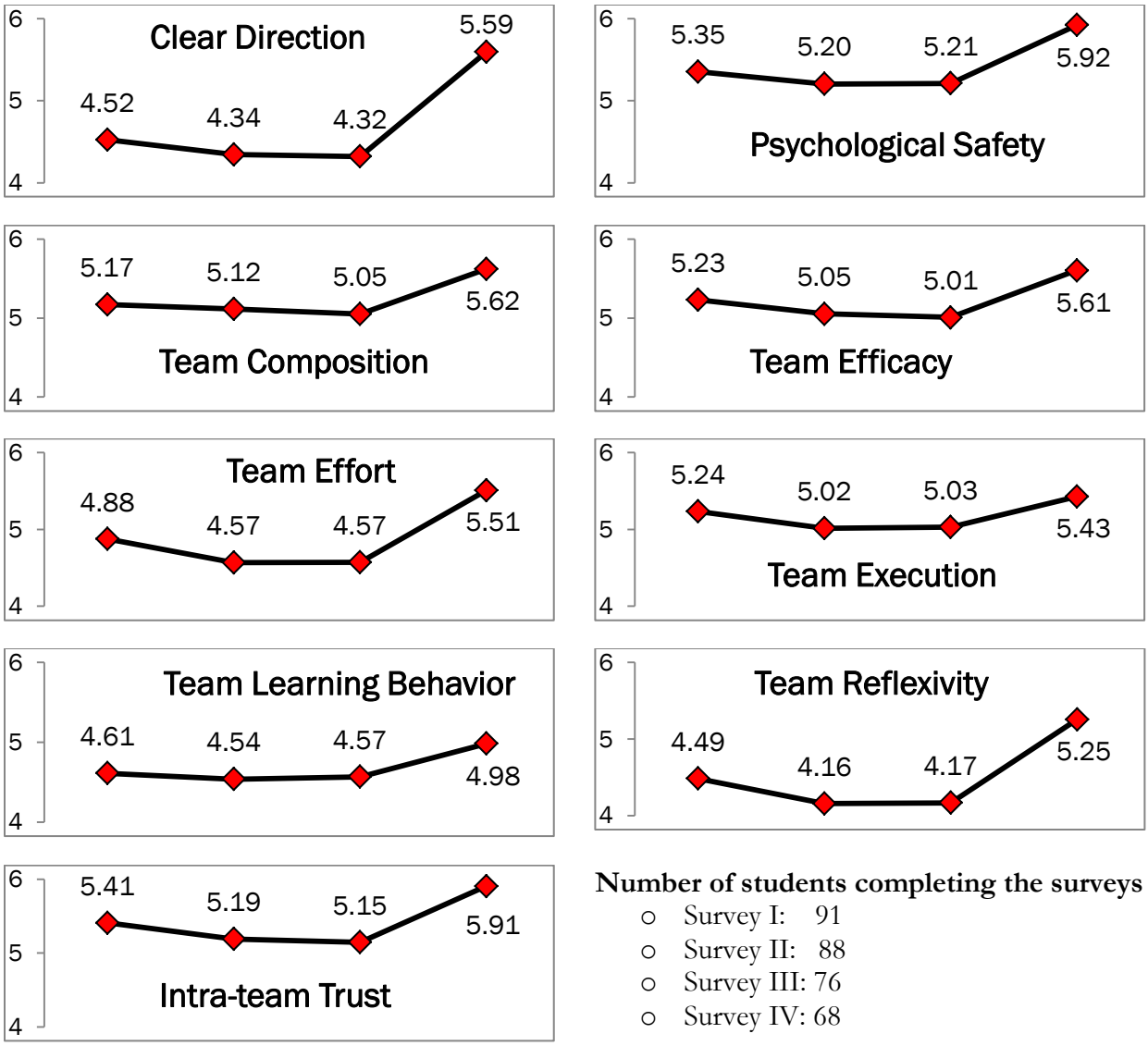


Exhibit 3: Progression of The Fresh Connection game



Number of students completing the surveys

- Survey I: 91
- Survey II: 88
- Survey III: 76
- Survey IV: 68

Exhibit 4: Average values of teamwork constructs over time

Teamwork Construct	from I to III	from I to IV	from III to IV
Clear Direction	0.395	**0.000**	**0.000**
Intra-team Trust	0.171	**0.001**	**0.000**
Psychological Safety	0.400	**0.000**	**0.000**
Team Composition	0.705	**0.005**	**0.004**
Team Efficacy	0.249	**0.041**	**0.007**
Team Effort	0.176	**0.001**	**0.000**
Team Execution	0.216	0.237	**0.017**
Team Learning Behavior	0.886	**0.018**	**0.023**
Team Reflexivity	0.196	**0.000**	**0.000**

Exhibit 5: p-values of change in evaluation of teamwork constructs between surveys (Welch's t-test; Unequal sample, unequal variance)

Teamwork Construct	from I to III	from I to IV	from III to IV
Clear Direction	0.874	**0.000**	**0.000**
Intra-team Trust	0.339	**0.009**	**0.002**
Psychological Safety	0.501	**0.000**	**0.000**
Team Composition	0.585	**0.015**	**0.020**
Team Efficacy	0.377	0.260	0.112
Team Effort	0.311	**0.022**	**0.001**
Team Execution	0.256	0.236	**0.014**
Team Learning Behavior	0.143	**0.000**	0.106
Team Reflexivity	0.273	**0.006**	**0.000**

Exhibit 6: p-values of change in evaluation of teamwork constructs between surveys (Paired t-test, n=48)

	2	3	4	5	6	7	8	9	10	11
1. Team ROI	-0.91	0.16	0.22	0.22	0.23	0.18	0.17	0.13	0.15	0.30
2. Team rank		-0.20	-0.23	-0.25	-0.28	-0.21	-0.19	-0.14	-0.17	-0.32
3. Clear Direction			0.58	0.48	0.56	0.69	0.52	0.67	0.78	0.62
4. Psychological safety				0.63	0.57	0.59	0.60	0.59	0.60	0.70
5. Team Composition					0.56	0.45	0.48	0.51	0.45	0.61
6. Team Efficacy						0.62	0.53	0.52	0.56	0.61
7. Team Effort							0.53	0.59	0.68	0.56
8. Team Execution								0.42	0.46	0.47
9. Team Learn. Behavior									0.65	0.57
10. Team Reflexivity										0.52
11. Intra-team Trust										

Exhibit 7: Correlations between individual students' evaluations of teamwork constructs and team performance (All four surveys)

	Team Performance (ROI)		
Predictor variable	**Model 1**	**Model 2**	**Model 3**
Constant	-27.05 ***	-40.98 *	-45.52 ***
Team Characteristics:			
Clear Direction	- 0.33		
Intra-team Trust	2.99 **		4.15 ***
Psychological Safety	0.30		
Team Composition	0.46		
Team Efficacy	0.94		
Team Effort	0.20		
Team Execution	0.21		
Team Learning Behavior	- 1.15		
Team Reflexivity	- 0.03		
Individual Attributes:			
Gender (M=1, F=0)		0.87	
Age		0.76	
Work experience (years)		-0.17	
GMAT-Quantitative (percentile)		-7.85	
GMAT-Verbal (percentile)		-4.86	
GMAT-Analytical (percentile)		25.11 ***	19.80 ***
Class rank		0.32 *	0.23 *
n	9	7	3
df	298	113	117
R^2	0.100 ***	0.176 **	0.251 ***
Adjusted R^2	0.073 ***	0.124 **	0.232 ***

† $p < .10$; * $p < .05$; ** $p < .01$ *** $p < .001$

Exhibit 8: Effect of team and individual attributes on team performance (All four surveys)

Factors	*df*	Sum of Squares	F value
Chat	1	3	0.017
Emails	1	41	0.266
Phone Calls	1	856	5.590 *
Skype or Google Audio	1	327	2.137
Skype or Google Audio/Video	1	0	0.003
Social Networks	1	407	2.659
Text Message	1	31	0.200
Residuals	197	30160	
* $p < .05$; ** $p < .01$ *** $p < .001$			

Exhibit 9: ANOVA of team performance vs. use of communication methods (Yes or No) by global virtual teams

Factors	*df*	Sum of Square	F value
Meeting Time	4	631	1.036
Team Attendance	4	1033	1.694
Meeting Time * Team Attendance	11	1358	0.810
Residuals	218	33230	
* $p < .05$; ** $p < .01$ *** $p < .001$			

Exhibit 10: ANOVA of team performance vs. team engagement by global virtual teams

Factors	*df*	Sum of Square	F value
Response: "Clear Direction"			
Gender	1	3.1	1.395
Age Group	3	13.3	1.978
Origin (Region)	6	18.8	1.406
Program	3	18.5	2.746 *
Residuals	295	659.2	
Response: "Intra-team Trust"			
Gender	1	0.8	0.638
Age Group	3	2.9	0.773
Origin (Region)	6	9.5	1.272
Program	3	3.8	1.006
Residuals	295		
Response: "Psychological Safety"			
Gender	1	1.23	1.371
Age Group	3	1.33	0.494
Origin (Region)	6	12.87	2.396 *
Program	3	4.7	1.748
Residuals	297	265.92	

Table continued on next page

Response: "Team Composition"			
Gender	1	0.7	0.526
Age Group	3	3.9	0.915
Origin (Region)	6	16.0	1.898 †
Program	3	6.5	1.545
Residuals	298	418.1	
Response: "Team Efficacy"			
Gender	1	2.8	1.940
Age Group	3	3.3	0.763
Origin (Region)	6	3.6	0.423
Program	3	7.0	1.635
Residuals	297	423.2	
Response: "Team Effort"			
Gender	1	0.0	0.007
Age Group	3	6.3	1.234
Origin (Region)	6	7.5	0.732
Program	3	16.4	3.227 *
Residuals	297	504.1	
Response: "Team Execution"			
Gender	1	0.15	0.145
Age Group	3	5.14	1.666
Origin (Region)	6	4.09	0.663
Program	3	5.06	1.643
Residuals	297	305.22	
Response: "Team Learning Behavior"			
Gender	1	0.01	0.005
Age Group	3	4.66	1.500
Origin (Region)	6	5.48	0.882
Program	3	3.02	0.971
Residuals	297	307.48	
Response: "Team Reflexivity"			
Gender	1	3.7	1.918
Age Group	3	11.4	1.949
Origin (Region)	6	18.5	1.580
Program	3	10.8	1.846
Residuals	298	582.5	

† $p < .10$; * $p < .05$; ** $p < .01$ *** $p < .001$

Exhibit 11: ANOVA of team constructs against demographic variables of team members

Teamwork attribute	Extraversion / Introversion	Intuition / Sensing	Feeling / Thinking	Judging / Perception
Clear Direction	0.775 (p = 0.380)	0.427 (p = 0.514)	0.327 (p = 0.568)	0.571 (p = 0.451)
Intra-team Trust	2.606 (p = 0.108)	0.012 (p = 0.913)	0.772 (p = 0.381)	0.119 (p = 0.730)
Psychological Safety	2.917 † (p = 0.089)	0.837 (p = 0.362)	0.955 (p = 0.330)	0.185 (p = 0.668)
Team Composition	3.284 † (p = 0.071)	0.031 (p = 0.860)	0.910 (p = 0.341)	0.195 (p = 0.660)
Team Efficacy	2.895 † (p = 0.090)	0.324 (p = 0.570)	0.125 (p = 0.724)	0.021 (p = 0.886)
Team Effort	1.736 (p = 0.189)	0.029 (p = 0.865)	0.406 (p = 0.525)	0.263 (p = 0.608)
Team Execution	2.567 (p = 0.111)	0.134 (p = 0.715)	0.001 (0.973)	0.373 (p = 0.542)
Team Learning Behavior	0.125 (p = 0.725)	0.045 (p = 0.833)	1.738 (p = 0.189)	0.008 (p = 0.931)
Team reflexivity	2.682 (p = 0.103)	0.645 (p = 0.423)	2.155 (p = 0.144)	1.766 (p = 0.185)
For every teamwork attribute whose variation is explained by the Extraversion / Introversion variation at $p \leq 0.1$, the average assessment by the Extroverts is higher than that by the Introverts.				

Exhibit 12: Results of ANOVA of MBTI and teamwork attributes: F statistics and p values