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The Impact of Virtuality on the Flexibility of Virtual Teams in Software Development Projects

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ABSTRACT

Despite widespread and growing prevalence of virtual teams, there is little understanding of the way virtual teams benefit from global distribution. Virtual teams are predicted by many to be the form that is much more flexible than traditional teams. As part of an ongoing research, in this paper we present a theoretical framework towards unraveling the relationship between the level of virtuality of a software development project team and its flexibility to respond to various environmental changes. Propositions are developed to identify the impact different dimensions of virtuality, viz., team dispersion, workplace mobility, and variety of practices, can have on flexibility to business changes, and flexibility to technological changes.

Keywords (Required)

Virtual team, Flexibility, Environmental change

INTRODUCTION

Virtual teams are not commonplace. Gartner Group predicted that 60% of the professional workforce will be working in virtual team by 2004 (Kanawattanachai & Yoo 2002). Today, around 40 percent of employees working with International Business Machines (IBM) in United States (US) have the option of working from home. Similar facility is available to 5000 employees of consulting firm KPMG in United Kingdom (UK). A recent study by market intelligence firm IDC suggests that the number of Americans working from home will triple from 112,000 to around 300,000 by the year 2010 (Rajawat 2007). The use of internet on the move is also rapidly rising. As of 2007, 55% of mobile internet users are between age 25 years to 44 years, and the current usage of mobile internet is dominated by work-related applications (Anonymous 2007).

Despite widespread and growing prevalence of virtual teams, there is little understanding of the way virtual teams benefit from global distribution. The academic as well as practitioner literature on virtual teams is still 'maturing' (Saunders & Ahuja 2006). Started as a cost reduction mechanism, virtual teams are now seen and predicted by many to be the form that is much more flexible than traditional teams (Beyerlein et al. 2001; DeSanctis & Jackson 1994; Gibson & Cohen 2003; Lipnack & Stamps 2000; Volberda 1998). As the high-tech industry faces challenges from a future that is hypercompetitive, where horizontal, unbundled component layers, will succeed (Kapur et al. 2003), the industry needs to induce greater flexibility to respond and incorporate environmental changes to remain viable in changed conditions. In software industry today, more projects are run in geographically distributed environments than before, and use of virtual teams is a norm (Damian & Moitra 2006).

This study focuses on understanding the relationship and impact of the degree of virtuality of a software development project team on the team's flexibility to respond to various environmental changes. The research questions for which answers are sought are: *What is the impact of the level of virtuality on the flexibility of a virtual team in software development? Do different dimensions of virtuality affect the flexibility of such virtual teams?*

VIRTUAL TEAM LITERATURE

Virtual teams have been defined in various ways in the literature. They are seen as temporary teams, assembled on an as-needed basis for the duration of the task (Powell et al. 2004), or ongoing teams, organized around well-defined, long-term, interdependent tasks (Saunders & Ahuja 2006). Highlighting the dispersed nature of virtual teams they are termed as teams crossing time zones, distance, and organizational boundaries through use of technology (Lipnack & Stamps 2000). Putting distribution and use of information and communication technologies together, virtual teams are defined as groups of geographically, organizationally, and/or time dispersed workers brought together by information and communication technologies to accomplish one or more organizational tasks (Powell et al. 2004).

Virtual teams are acknowledged as teams first; they work in an organizational setting, have shared goals and task interdependence (Horvath & Tobin 2001). Table 1 below depicts similarities and differences between virtual teams and teams referred in the traditional sense. When objectives of a project are modularized and then distributed, where the modules are completely independent with no interaction needed, such project teams, even though distributed, do not fall into our purview of virtual teams. Secondly, virtual teams use information and communication technologies (ICT) for most of their communication. Thus teams where members even though being in the same city or office complex, use ICT for most of their communication, than face-to-face meetings, will constitute virtual teams (Kirkman & Mathieu 2005).

Virtual Teams	All Teams	Traditional Teams
Geographically dispersed	Multiple individuals	Face to face
Communication through technology	Task interdependence	Communication primarily in person
	Shared goals	
	Organizational setting	

Table 1: Distributed teams vs. traditional teams (Horvath & Tobin 2001).

Virtual organizing is a strategy applicable to every organizational structure. Virtualness is a strategic characteristic (Venkatraman & Henderson 1998). We define virtual organizing as “a strategy of organizing software development project teams as groups of individuals who work together in different locations, work at interdependent tasks, share responsibility for outcomes, and rely on technology for much of their communication” (Gibson & Cohen 2003). *A project team organized according to this strategy is called a Virtual Team.*

Benefits of virtual organizing

Virtual work, in the form of virtual office, virtual team, distributed team, etc., enables firms to take work to places where it can be done most effectively (Lacity & Willcocks 1998). With geographical dispersion of members across different time zones, firms can adopt follow-the-sun approach where work goes on continuously on a project (Hertel et al. 2005). Members, leaving office in one part of the world, handover their day’s work to members coming to office, in another part of the world, to carry it forward (Lipnack & Stamps 2000). In addition to reducing costs, global distribution also allows to reach out to experts irrespective of location where they are present (Desanctis & Monge 1999). It is very difficult to find all the required experts in one office/city. Neither is it feasible to move experts around the world wherever their expertise is needed. The solution is to bring the work to experts rather than vice versa (Lurey & Raisinghani 2001). This also reduces travel costs (Fuller et al. 2007). Virtual teams also enable greater proximity to customer with a small portion of the team located close to the customer while the remaining team members are spread all across the world (Gibson & Cohen 2003). Global distribution makes it easier to quickly build teams for task at hand by putting together resources that are available, irrespective of location. Dissolution of the team, once the task finishes, is equally effortless (Beranek & Martz 2005). This flexibility enables faster planning of responses to various challenges that are faced in hypercompetitive environments.

Difficulties in managing virtual teams

On the other hand, increased heterogeneity caused by temporal and geographical dispersion of virtual teams raises many hindrances for coordination of efforts (Fritz et al. 1998). Virtual work requires a high degree of communication and coordination between people at multiple locations (Boudreau et al. 1998) due to loss through information transfer, caused by the inherent leanness of the electronic media to transfer non-verbal cues (Zack 1993). Communication in virtual team is never as complete as it can be in a face-to-face interaction (Chidambaram & Jones 1993). In a distributed arrangement, communication within and among the teams is generally less effective despite the latest tools and technologies being made available (Chidambaram & Tung 2005). This makes coordination of team effort very challenging (Hinds & Bailey 2003). Paucity of communication and difficulty in coordination exacerbates the cultural differences among team members, which are caused due to people with different backgrounds from all over the world coming together to form the team (Sarker et al. 2005). Also this makes it difficult to develop trust between the team members (Piccoli & Ives 2003).

Virtuality dimensions

Various studies have tried the dimensional analysis of the team virtuality (Griffith et al. 2003; Kirkman & Mathieu 2005). Chudoba et al (2005) developed a three dimensional model of virtuality of teams viz., team distribution, workplace mobility,

and variety of practices. Team distribution is the degree to which people work on teams that have members dispersed over different geographies and time zones. For this study we are calling the term as **Team Dispersion** instead of Team Distribution to identify the geographical dispersion of the team as a dimension of overall distributedness of the team. **Workplace mobility** is the degree to which employees work in environments other than regular offices, including client sites, home, travel routes, etc. **Variety of Practices** is the degree to which employees experience cultural and work process diversity on their team (Chudoba et al. 2005).

FLEXIBILITY LITERATURE

The management literature follows a partial approach here and flexibility is always defined with respect to certain aspects of the organization (functional approach), or with respect to certain stakeholders in the organization (actor approach) (Volberda 1998). There are various definitions proposed with flexibility treated as manufacturing flexibility (Upton 1994), strategic flexibility (Eppink 1978; Evans 1991), information systems infrastructure flexibility (Weill et al. 2002), labor flexibility (Molleman & Slomp 1999), etc. All the specific definitions of flexibility emphasize upon the ability to quickly and effectively adapt to environmental changes. Flexibility is the ability to change or react with little penalty in time, effort, cost, or performance (Upton 1994).

According to Krijnen (1985), a firm is flexible when it has the ability to change itself in such a way that it remains viable in the new environment. The firm adapts to circumstances that were by no mean predictable. If environmental changes are predictable then planning can be done by taking into account the developments in the environment that are likely to occur. On the other hand, the firm may develop activities by which it tries to influence the environment so that the firm does not have to adapt itself (Krijnen 1985). A firm is flexible if the necessary changes can be made at operational, organizational, and strategic level (Krijnen 1985).

Environmental changes have been classified in many ways. According to the origin of change it can be internal or external change (Ansoff 1965); by the level of impact it can be operational, tactical, or strategic change flexibility (Eppink 1978). If the source of change is within the team boundary then it is an internal change, if the source lies outside the boundary then it is an external change. External changes faced by global software development project teams can be further classified as business changes or technical changes. Coming from the end-user, a **business change** can change the stated objectives for the project team; a **technological change** can affect the work process in turn forcing the project team to redesign the software (Lee 2003).

A project team is the main form of work organization in software development firms. More flexible project teams add to the flexibility of the firm to remain viable in changed environments. Virtual organizing of project teams makes them more flexible. Among various classes of flexibility maneuvers as shown in Fig 1, we focus only on the reactive capability of virtual teams. It is argued that in hypercompetitive environments the predictability of occurrence of environmental changes is very low, but the impact of an unforeseen environmental change can be potentially severe (D'Aveni 1995; Eisenhardt 1989). In such environments it is advisable to build capability to quickly react to a change and adapt to new conditions, instead of trying to predict the change and controlling for it. Software development teams are facing higher levels of hypercompetition in their environments (Herbsleb & Moitra 2001). To survive in such conditions they must learn to be adaptive and respond effectively, i.e., incorporate as much of the change possible into their working, and to do it using minimum effort and resources in minimum time. Thus, we take all the environmental changes as given; not considering the root cause of the change but only focusing on the reactive capability of the software development team. This capability we call as the flexibility of the team.

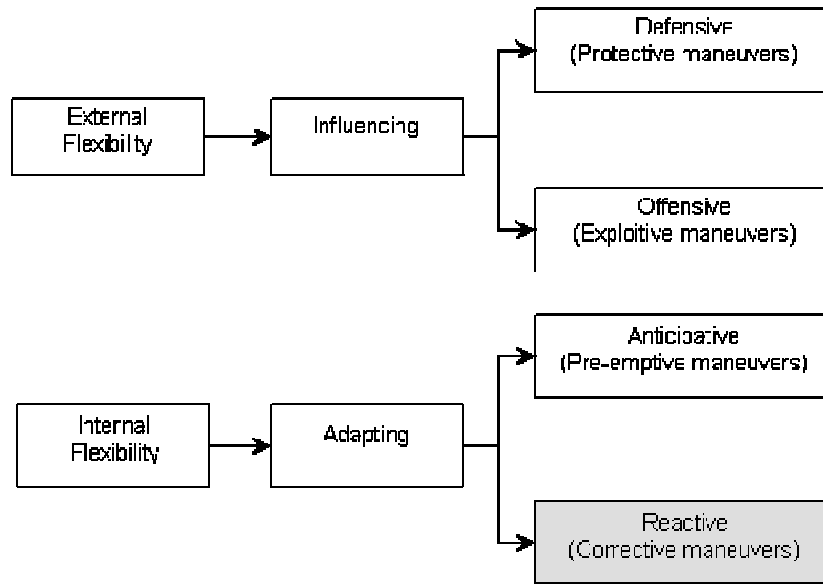


Figure 1: Flexibility classification (Volberda 1998)

RESEARCH MODEL

Taking examples from published literature we illustrate the kind of flexibility displayed by virtual teams, and the factors which contributed to this flexibility in Table 2.

Case	Factors contributing to the flexibility	Flexibility displayed	Reference
Rocketdyne	<ul style="list-style-type: none"> - Access to diverse knowledge resources - Varied perspectives improve decision quality - Improved group decision process 	<ul style="list-style-type: none"> - Business change <i>Sudden surge of cheaper Russian engines in the market</i> - Technological change <i>A new radically simpler and cheaper engine design</i> 	(Majchrzak et al. 2004)
Unilever Latin America	<ul style="list-style-type: none"> - First-hand local information improves decision quality - Improved group decision process 	<ul style="list-style-type: none"> - Business change <i>Redesign of product needed for new markets</i> 	(Majchrzak et al. 2004)
IBM	<ul style="list-style-type: none"> - Quicker team building - Easier to add experts when needed 	<ul style="list-style-type: none"> - Business change <i>Modifications to be made in proposal to counter rival</i> 	(Engardio 2007)
Carruthers Corp	<ul style="list-style-type: none"> - Access to diverse knowledge resources - Quicker team building 	<ul style="list-style-type: none"> - Business change <i>Sudden exit of supplier of key ingredient</i> - Technological change <i>Production process changes due to the new ingredient</i> 	(Majchrzak et al. 2004)
E-Commerce	<ul style="list-style-type: none"> - First-hand local information improves decision quality 	<ul style="list-style-type: none"> - Technological change <i>Localization of software to suit the international context</i> 	(Haywood 2000)
IBM	<ul style="list-style-type: none"> - Reduced time to market (<i>outcome</i>) 	<ul style="list-style-type: none"> - Technological change <i>Significant modifications in custom-built code</i> - Business change <i>Changing requirements in the new context</i> 	(Treinen & Miller-Frost 2006)

VeriFone	- Reduced time to market (<i>outcome</i>)	- Business change <i>Quick building of business proposal to counter rivals</i>	(Peters 1994)
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Table 2: Factors contributing to flexibility and Flexibility displayed

Based on illustrations above, we now develop a framework of relationship between virtuality and flexibility of virtual teams in software development projects.

FLEXIBILITY TO BUSINESS CHANGES

For each project, a software development team is constituted “de novo” (Faraj & Sproull 2000). These project teams have a predefined set of objectives to achieve, and quality to be maintained, as stated in the requirements (specifications) document. This document, more often than not, is altered by various change requests coming from the client and the end-users. These change requests may arise due to a variety of reasons. If the initial requirements gathering and analysis was not done properly, then the client may raise objections and demand changes during prototype evaluation or user acceptance test (UAT). Sometimes the end-users themselves are not clear of the exact requirements and thus make suggestions during the prototype evaluation. During the course of development, the client may wish to optimize its operations by reengineering some processes. This requires realigning the project objectives to conform to the new system. This category of environmental changes is called *business changes*.

Business changes include changes in objectives of the system, system scope, delivery date, budget, system input data, system output data, business rules transforming input data into output, data structure, system response time, system reliability, user interface, etc. Most of these changes are beyond the immediate control of the project manager (Lee 2003). When a requirement change request from the end-user surfaces the project team needs to address the same by incorporating this into the software.

To respond to business changes in an effective and efficient manner, a project team needs to identify the change, understand it fully, devise a counter strategy, and reorient itself according to new requirements. All these activities should be done in least possible time and with minimum efforts.

Virtual organization of project teams disperses team members across various geographical locations. Team dispersion allows utilizing time-zone differences to reduce the cycle time. This is done by applying Follow-the-Sun approach. Team members who are present close to the client provide crucial liaison with client to identify and understand the change request in detail. These team members can obtain first hand information about the background of the change request and exchange team ideas with the client to clarify all doubts. This can also be achieved by positioning the entire project team at the client location, but the strategy is prohibitively expensive. Thus team dispersion helps in improving the flexibility to incorporate business changes. Thus we say that,

P1: *Team dispersion positively affects the flexibility to respond to business changes.*

Virtual organizing of project team allows team members to work anytime and from anywhere. This mobility of the workplace allows project team members to be connected with each other under all circumstances. Also team has the flexibility to have working schedule that fits everyone’s constraints, at the same time allowing most suitable synchronous working. The business changes can be easily communicated to everyone and a joint decision on the further course of action can be quickly taken. Thus we say that,

P2: *Workplace mobility positively affects the flexibility to respond to business changes.*

Virtual organizing of project teams brings in people who differ in terms of perspectives, work practices, professional background, etc together in the team. Thus virtual teams have greater diversity as compared to collocated teams. This diversity exhibited as the variety of practices among project team members increases communication hurdles, but when managed properly enables team to come up with creative and robust solutions by incorporating wide-ranging ideas. As described by (Majchrzak et al. 2004)

“... The languages of their various disciplines were so dissimilar that, for a while, the engineers, analysts, and rocket scientists couldn’t understand each other. ... But the clash of perspectives produced solutions instead of acrimony.”

Having access to differing perspectives significantly improves the process and quality of decision making. In collaborative-learning systems it was found that distant teams had higher critical-thinking skills (Alavi et al. 1995). Heterogeneous groups were found to score more on range of perspectives, and alternatives generated (Watson et al. 1993). Thus we say that,

P3: Variety of practices positively affects the flexibility to respond to business changes.

FLEXIBILITY TO TECHNOLOGICAL CHANGES

The technological environment within which the software development takes place may itself change. Technological changes include changes in programming languages, system analysis/design methodologies, the IT architecture, network/telecom environment, other systems that this system would interface with, enterprise master data that this system used, the IT infrastructure, the system development tools/technologies, etc.

Technological changes take place due to mainly two reasons. First, when something new comes up in the technological domain which better suits the project development requirements, it calls for mid-course changes. To a large extent these changes are known in advance to expert developers through various professional forums that they are member of, and also through the beta versions that are released for testing purposes. Sometimes clients themselves ask for some specific emerging technology to be implemented as it fits in their larger scheme. These changes even though known in advance may have serious implications on the project team performance, if they are not handled properly.

Incorporating emerging technologies require the project team to gather as much information about it as possible. A new technology, unless disruptive, is generally an extension or improvement of an existing technology. When detailed information is available, it's generally very easy for team members, who are experts in the last version of the technology, to learn the modifications. By virtue of having people in different geographical locations, virtual teams have access to diverse sources of knowledge. This enables people to gather information from multiple sources which enable knowledge combination and application. Members of a virtual team have non overlapping social network, as opposed to members of a collocated team. Members of a virtual team can thus utilize the knowledge resources available with other team members who might be located elsewhere and exploit the knowledge gained, to enhance team functioning. Thus we say that,

P4: Team dispersion positively affects the flexibility to respond to technological changes.

Secondly, sometimes, over the lifecycle of the project, it is realized that the technology that was selected initially over the other, is proving inadequate to fulfill the project requirements. To manage such changes in the technological environment, the project team should quickly add members who are expert in that technology into the team. Workplace mobility allows easy addition of expertise to the team. Technological experts can be a member of the project team and contribute to the working from wherever they are located and do not need to change place. Use of ICT enabled communication facilitates working from different locations. It allows the members to be connected with the team under all circumstances. This provides the manager with flexibility to alter the team's composition to best fit the requirements. Thus we say that,

P5: Workplace mobility positively affects the flexibility to respond to technological changes.

MODERATING EFFECTS

Virtual organizing is a radically different form of team formation than the traditional collocated setting. It takes some time for new and inexperienced members to get accustomed to virtual setting. Virtual team work characterized by temporal and geographical distribution, and electronically mediated communication, calls for a different approach towards the work process. To be successful, the communication in virtual team should be precise, concise, and unambiguous. Working with team-mates who never met face-to-face requires a different mindset. These qualities develop gradually in new comers, taking time for them to get used to the virtual environment and reach their full potential. For example, in one distributed project in IBM, when the lead project manager had to leave the team, they were able to manage this sudden change with little disruption due to the "maturity and experience of the rest of the team" (Treinen & Miller-Frost 2006). A team with lesser experience of virtual environment would have failed in such a situation. Lack of experience makes it difficult for new comers to fully understand the gravity of a conflict and complexity of the work process in virtual setting. More experience the team has of working in similar environs, easier it is for them to understand the situational cues and quickly reach at the most proper response (Ahuja & Galvin 2003). Thus we see that prior experience of working in virtual setting moderates the relationship between virtuality and team flexibility. Hence we say that,

P6: As the experience of the team members increases, level of team virtuality has a greater positive impact on the flexibility of the project team.

Technical infrastructure provides the backbone for the virtual team to work effectively. Better connectivity enabled IBM to quickly assemble a team of experts from around the world to respond to rival tactics (Engardio 2007). The online virtual workspace created at Shell helped team members to connect well with each other, easily share information, coordinate efforts, and discuss issues in a more effective manner (Majchrzak et al. 2004). On the other hand, the lack of connectivity at the remote location in a project at IBM caused enormous delays and rework efforts. Due to remote team not being able to connect to the client systems directly, an extra step had to be included in the whole process making it difficult and time consuming (Treinen & Miller-Frost 2006). Thus we say that,

P7: Better the technical infrastructure support to the virtual team, greater is the positive impact of the level of team virtuality on the flexibility of the project team.

Based on the above discussion we propose the research model as shown in the figure below.

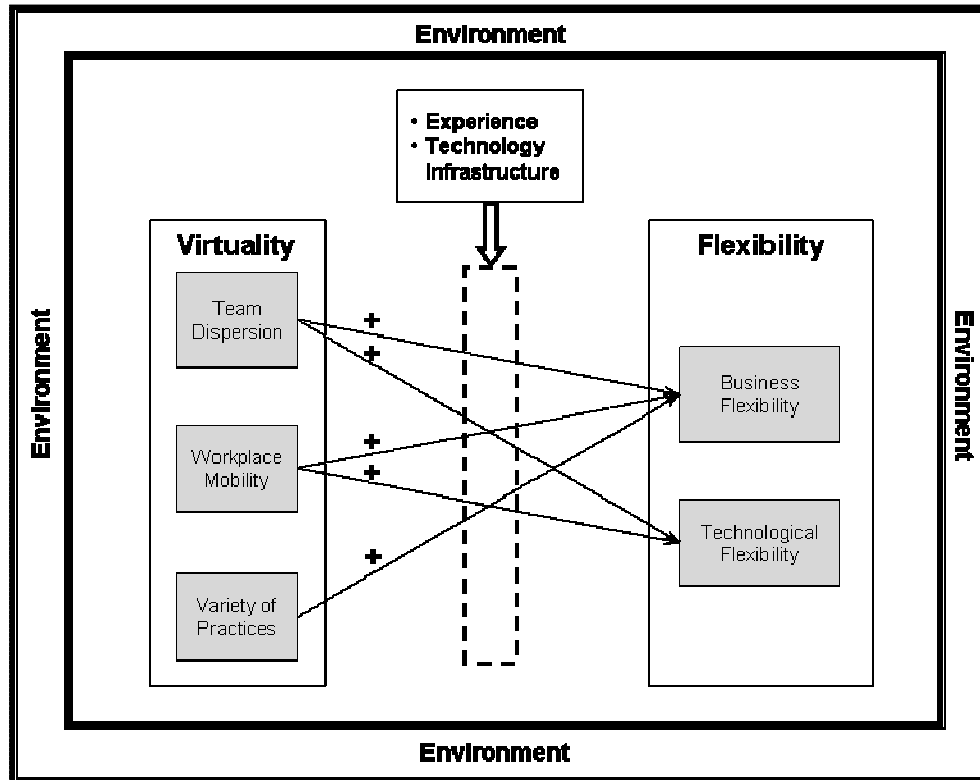


Figure 2: Research Model

CONCLUSION

The relationship between the virtuality and the flexibility of global software development project teams has not been looked at so far. An attempt is made here to develop a theoretical framework for the relationship. We plan to validate the model through structured survey based research with analyzing the data through LISREL. The data collection for the same is underway.

Most studies done on virtual teams are either experimental in nature or focus on case study research. These studies were either performed within the context of a virtual team, or take virtuality to be a dichotomous variable. Virtuality is presented, and measured as a continuous variable here. This study, based on primary field survey data, will help in statistically establishing and measuring the strength of the relationship between various dimensions of virtuality and flexibility of GSD project teams. This study also validates and improves upon the measures for virtuality and flexibility.

For practicing project managers and team leaders, knowing the strength of this relationship will help in better design of GSD project teams. Better understanding of the strength and impact of various dimensions of degree of virtuality of teams on the

flexibility to respond to environmental changes will help practitioners to better manage the nuances of GSD project teams. Improved design and better management in turn enhances the performance of teams, and thus software firms.

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