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## ABSTRACT

Virtual teams are predicted by many to be the form that is much more flexible than traditional teams. In this paper we execute empirical analysis of the theoretical framework presented earlier. Data was collected through an online survey of the Information Systems specific interest group of Project Management Institute, and executive students at IIM Bangalore. Arguing flexibility to be a formative construct, the data was analyzed using PLS. It was found that virtuality positively and significantly affects flexibility, moderated by technology infrastructure, and team experience.

### Keywords

Virtual team, Flexibility, Environmental change, Competitive advantage

## INTRODUCTION

Bakshi and Krishna (2008) in their earlier work presented the propositions towards the relationship between different dimensions of virtuality, and the flexibility to respond to environmental changes for a software development project team. The paper presented the benefits and challenges faced by virtual teams and further focusing on the corrective maneuvers undertaken by firms to react to environmental changes, discussed the potential strategic enhancements offered by virtual organizing of project teams.

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*. Virtuality of a project team has been argued to be a continuum (Griffith, Swayer, and Neale 2003) with three dimensions viz. Team Dispersion, Workplace Mobility, and Variety of Practices (Chudoba et al 2005).

Considering the flexibility provided by the organizational characteristics of projects teams, we define flexibility as the ability of project teams to react to environmental changes. The two types of flexibility considered in the paper are flexibility to business changes and flexibility to technological 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). The research model from Bakshi and Krishna (2008) is as presented in the Figure 1 and the hypotheses are listed below.

H1: *Team dispersion positively affects the flexibility to respond to business changes.*

H2: *Workplace mobility positively affects the flexibility to respond to business changes.*

H3: *Variety of practices positively affects the flexibility to respond to business changes.*

H4: *Team dispersion positively affects the flexibility to respond to technological changes.*

H5: *Workplace mobility positively affects the flexibility to respond to technological changes.*

The paper also argued that the experience of the project team and the availability of a technology infrastructure to support the virtual work, are two moderators affecting the relationship between virtuality and flexibility. The hypotheses about the same are as below.

H6: *As the experience of the team members increases, level of team virtuality has a greater positive impact on the flexibility of the project team.*

H7: *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.*

Please refer Bakshi and Krishna (2008) for details about these hypotheses. We now present the measurement scales used, data collection exercise, and finally the results of data analysis, and discussion in following sections.

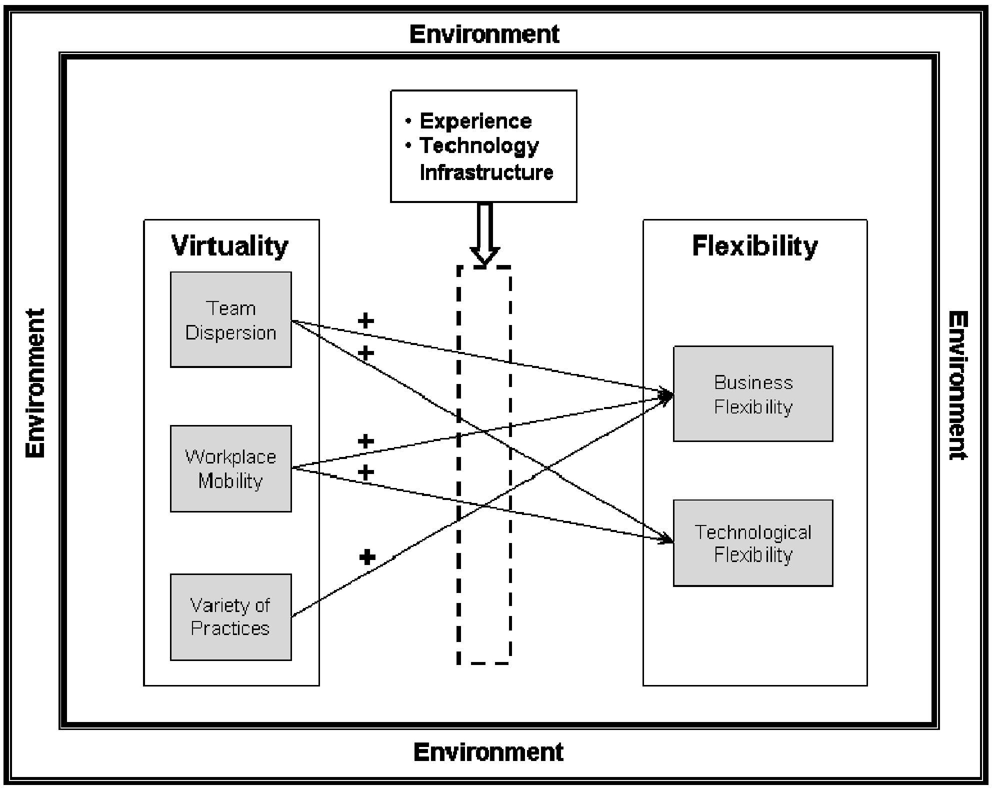


**Figure 1: Research Model**

## MEASUREMENT SCALES

### Virtuality measure

The scale as reported in Chudoba et al (2005) defines three dimensions of the virtuality of a team viz., team distribution, workplace mobility, and variety of practices. The original scale measured the frequency of occurrence of items over a six point scale consisting of never, yearly, quarterly, monthly, weekly, and daily. But the frequency 'quarterly' for a project of duration 5 months is not as frequent as for a project of duration two years. To make the frequencies comparable and collate over different project sizes, it was decided to use a 5-point Likert scale ranging from 'very often' (1) to 'never' (5). The scale is actually a reverse scale with lower numbers representing more frequent occurrence of discontinuities. To make all scales pointing in same positive direction, the scale responses were reversed (subtracted from 6) and then used in analysis.

One item in the original scale asked for frequency of collaboration with people who speak different native languages or dialects. Virtual teams in software development, by virtue of geographical dispersion, bring together people from different cultural backgrounds. These people are professionals and as long as there is any one common language of expression, they can work together very well. Thus the item was modified to 'frequency of collaboration with people who have similar comfort level with the common language of expression'. When team members have a common language of expression, the virtuality of the team reduces. Finally a 13 item scale was used after cleaning, consisting 5 items for team distribution and 4 items each for workplace mobility and variety of practices.

### Flexibility measure

The flexibility of global software development project teams is defined as the team's capability to effectively and efficiently respond to project environment changes (Lee 2003). The sources of change are classified into changes from end-user requirements modifications called business changes, and changes due to change in the technical domain like the programming language, system analysis/design methodologies, IT architecture, etc., called technological changes (Lee 2003).

Flexibility was calculated by measuring the extent of change incorporation and excess effort needed for integrating the change. For eleven categories of changes in business domain and seven categories in technology domain the respondents were asked to rate the extent of change incorporation and additional efforts required for the same on a five-point Likert scale ranging from 'Less' to 'Much'. Lee 2003 refers these as extensiveness and efficiency. For the purpose of this study, it was decided to build one index of Flexibility rather than using extensiveness and efficiency separately as done by lee 2003. The study indicated that there is strong negative correlation between the two characteristics. Thus the ratio of extensiveness and efficiency was taken to create one index. This way flexibility can be defined as "*amount of change incorporated per unit of effort spent*". This index penalizes the project team for excessive usage of resources for change incorporation. Lowest value that flexibility can achieve is when minimum change ('Less' = 1) was incorporated by spending maximum effort ('Much' = 5), which is 0.2. Similarly, the maximum value can be 5 when all change was incorporated without spending much extra effort.

### Experience

Experience level of an individual can be assessed easily in terms of the time spent by the individual working on the particular characteristic or expertise. Experience level of a team can be a rather tricky one to measure. It can be done in two ways. First, for any particular capability or characteristic, the experience of individual team members can be aggregated to arrive at the team experience. The second approach used by Faraj and Sproull (2000) measured the availability of expertise in a team by taking the proportion of team members with the requisite expertise. In this study respondents are asked to provide the proportion of team members who had experience of working with multi-location teams, with each other, on projects of similar complexity, similar technology, and experience of working for the client.

### Technology Infrastructure

The scale to measure the technology infrastructure has been adopted from Byrd & Turner (2000). The paper develops the technical and human dimensions of the IT infrastructure of a firm and prepares scale to measure the same. IT infrastructure is measured in terms of IT connectivity, applications functionality, IT compatibility, and data transparency. Total nine items were selected, which were seen to be most relevant for virtual teams.

## DATA COLLECTION & METHOD

The data collection was done using a structured questionnaire administered online to all the participants. LimeSurvey, an open-source software, was installed on one of the Indian Institute of Management Bangalore (IIMB) servers and the survey link was sent to target respondents through email invitations. Two sources of respondents were used in the study. The first source consists of the members of the Project Management Institute – Information Systems Specific Interest Group (PMI-ISSIG[1]). PMI-ISSIG is the special interest group of PMI with information systems project managers from across the globe as members. The second source consisted alumni and current students of the Post Graduate Program in Software Enterprise Management (PGSEM) at IIMB. PGSEM is an executive program designed for the specific needs of professionals working in the software and information technology industry in India[2]. As we consider virtuality to be a continuum, the survey link was sent to all respondents. The invite clearly specified that only project managers, consultants, or leads having completed at least one project, and knowing the overall parameters and outcomes of the project should respond.

Two identical copies of the questionnaire were created to keep responses from PMI-ISSIG members separate from PGSEM respondents. One reminder was also sent to PMI-ISSIG members, while two reminders were sent to PGSEM students. To select usable responses, the records were sorted on the number of missing values in virtuality, flexibility, experience, and technology infrastructure availability respectively, the four variables in the model. All the records with not more than ten values missing were included in the study. Finally 157 responses from PMI and 85 responses from PGSEM, total 242 data points, were found usable for the study. The descriptives of the data are presented in Table 1. The variables respectively are

[1] www.pmi-issig.org
[2] http://pgsem.iimb.ernet.in/

Team Dispersion, Workplace Mobility, Variety of Practices, Business Flexibility, Technological Flexibility, Experience, and Technology Infrastructure availability.

| | *Mean* | *St Dev* | TD | WpM | VoP | BizFlex | TechFlex | Experience | TechInfra |
|---|---|---|---|---|---|---|---|---|---|
| **TD** | *2.631* | *0.880* | 1.000 | | | | | | |
| **WpM** | *2.997* | *0.851* | 0.375 | 1.000 | | | | | |
| **VoP** | *2.815* | *0.751* | 0.541 | 0.524 | 1.000 | | | | |
| **BizFlex** | *1.039* | *0.251* | 0.062 | 0.020 | -0.061 | 1.000 | | | |
| **TechFlex** | *1.017* | *0.279* | 0.007 | 0.035 | -0.032 | 0.351 | 1.000 | | |
| **Experience** | *2.863* | *0.850* | -0.076 | -0.143 | -0.098 | 0.091 | 0.055 | 1.000 | |
| **TechInfra** | *3.378* | *0.788* | -0.148 | -0.083 | -0.085 | -0.044 | 0.038 | 0.063 | 1.000 |

**Table 1: Data Descriptives and Correlation Matrix**

None of the variables was found to be normally distributed by the Shapiro-Wilk's test. This gives a strong indication that multivariate normality would also be absent. Testing the equality of mean and variance between the two samples collected from PMI and PGSEM sources, we found that the two samples are homogenous and the data points can be combined together. Non-response bias occurs when the targeted respondents fail to respond and consequently the data collected may turn out to be invalid (Muhamad Sori et al. 2006). The results of Mann-Whitney test comparing the first 20 and last 20 responses show that the significance values are too high to reject the null hypothesis that the two sub-samples come from the same population (Wallace and Mellor 1988).

### Formative vs. reflective construct

Correct specification of measures is very important. Structural paths emanating from both the miss-specified exogenous and endogenous formative constructs have large upward biases; however, path leading to a miss-specified endogenous construct has a downward effect. Miss-specifying endogenous formative constructs as reflective also reduces the power of the model (Petter et al. 2007).

The measures of team dispersion, workplace mobility, and variety of practices are discontinuities experienced by project teams when they are involved in virtual work. Here the indicators are manifestations of the underlying latent variable. Indicators within each dimension are interchangeable to an extent. For example, item 'Work while traveling', and item 'Work with mobile devices' are both measuring mobility of the workplace of team members. This is also substantiated by clean separation of items during factor analysis. Thus we say that team dispersion, workplace mobility, and variety of practices are reflective constructs.

The scales measuring business and technological flexibilities provide a list of various possible categories of changes in business and technological environment that project teams are exposed to. These change categories together constitute the flexibility. Flexibility to respond to changes in 'System scope' and 'Delivery date' are measuring two distinct aspects of business flexibility and one can not be substituted by the other. This shows that business flexibility and technological flexibility are formative constructs.

The covariance matrices of indicators show that even though there are indicators that covary in flexibility scale, the behavior is non-essential and coincidental, whereas indicators of virtuality dimensions show good internal correlation. Also given the nature of various change categories in the flexibility scale it is evident that each category has different antecedents and consequences. This again points to flexibility scales being formative and measure for virtuality dimensions being reflective in nature.

There are no well established procedures for cleaning up the measurement model for formative constructs (Helm 2005; Petter et al. 2007). Analysis of the measurement model presents some negative weights with low t-values. These weak indicators should be removed from the measurement model, but only if the breadth of the construct definition is not compromised (Helm 2005). Removing an indicator from formative construct may change the nature of the construct and so must be done if and only if permitted by theory (Diamantopoulos and Winklhofer 2001). Weak loadings can also be interpreted as not adding to the construct conceptualization in that particular construct (Fornell et al. 1990). This is not sufficient to prove that the model is not valid (Helm 2005). Thus following Fornell et al (1990), all indicators were preserved for the analysis.

### Partial least squares

Partial Least Squares (PLS) was developed by Herman Wold to be used in cases where the theory was weak, data was less, and assumptions about distributions can not be made (Chin et al. 2003). As the factors in PLS are orthogonal, multicollinearity is not a problem. This enables PLS to handle formative constructs. PLS is a 'soft modeling' technique, because it is free of multicollinearity and multivariate normality assumptions of regression. As the data points of some of the constructs involved in this model are not normally distributed (significant Shapiro-Wilk test), this strongly points to the absence of multivariate normality in the data. Also flexibility, as measured in this study, is a formative construct. Both these points suggested the use of PLS instead of covariance-based techniques like LISREL.

### SmartPLS

SmartPLS, developed by Christian Ringle, Sven Wende, and Alexander Will[3], is software that employs PLS for SEM. It is Java-based and is this independent of the operating system platform. The input to the system is raw data, but option is there for standardization. Missing values are handled either by case-wise or mean replacement. The software allows the choice between path, centroid, and factor weighting schemes. It also allows changing the initial weights which are by default 1.0. The t-values for checking the significance of relationships are calculated by re-sampling techniques of bootstrapping or blindfolding. It also provides support for finite-mixture PLS analysis.

The moderation effect in SmartPLS implements the product indicator approach provided by Chin et al (2003). The product indicator approach is a one-step technique that is independent of multivariate normality assumption, and can be used to estimate large complex models. The measures for interaction term are created by creating all possible products of standardized or centered indicators of predictor and moderator variable. This interaction variable, along with predictor and moderator variable, is then used for estimating the indicator variable using PLS procedure (Chin et al. 2003).

## HYPOTHESES TESTING

SmartPLS was supplied the raw data with option chosen for standardization by the software. The model was tested using path-weighting scheme, with case-wise-replacement of missing values, and initial values as 1.0. The quality parameters for the base model are presented in Table 2.

| | AVE | Composite Reliability | Cronbach's Alpha | Communality | TD | VoP | WpM |
|---|---|---|---|---|---|---|---|
| **BizFlex** | 0 | 0 | 0 | 0 | | | |
| **TechFlex** | 0 | 0 | 0 | 0 | | | |
| **TD** | 0.5481 | 0.8581 | 0.7956 | 0.5481 | **0.7403** | | |
| **VoP** | 0.6599 | 0.8846 | 0.8291 | 0.6599 | 0.6145 | **0.8123** | |
| **WpM** | 0.5582 | 0.8296 | 0.7553 | 0.5582 | 0.1010 | 0.3030 | **0.7471** |

**Table 2: Model quality parameters**

AVE (Average Variance Extracted) is the measure of variance captured by a construct compared to the amount of variance due to measurement error. AVE value of more than 0.5 is considered good for the discriminant validity of constructs. Table 2 presents the various quality parameters of the structural model. Last three columns in the table present the correlation between variables. The diagonal values, in bold, are the square root of the AVE. The value for each variable is greater than its correlation with every other variable. This establishes the discriminant validity of the reflective exogenous portion of the measurement model. From the table we can also see that composite reliability and Cronbach's alpha values are all above 0.75 thus establishing the good quality of the measurement model. The results of the PLS analysis of the structural model are as presented in Table 3.

[3] Ringle, C.M., Wende, S., Will, S.: SmartPLS 2.0 (M3) Beta, Hamburg 2005, http://www.smartpls.de

| **Hypothesis** | **Relationship** | **Coefficient** | **T Statistic** | **Hypothesis support** |
|---|---|---|---|---|
| *H1* | *TD → BizFlex* | *0.864596* | *15.686783**** | *Supported* |
| *H4* | *TD → TechFlex* | *0.683049* | *15.060552**** | *Supported* |
| *H2* | *WpM → BizFlex* | *-0.172191* | *2.290478*** | *Not Supported* |
| H5 | WpM → TechFlex | 0.094968 | 1.132287 | Not Supported |
| H3 | VoP → BizFlex | -0.102608 | 1.197074 | Not Supported |
| | VoP → TechFlex | -0.2593 | 2.2657 | |
| **Overall** | Virt → Flex | 0.860553 | 45.722490*** | *Supported* |
| ***: p<0.01; **: p<0.05; *: p<0.1 | | | | |

**Table 3: Final SEM results**

In the current study, the sample size of 242 is too small to perform subgroup analysis so moderator analysis using multiplier effects was performed using PLS. Results for moderator effect analysis are presented in Table 4. Positive coefficient of product term indicates that the main effect of predictor to indicator increases as the moderator increases. Similarly negative value indicates that the main effect decreases with increase in the value of moderator.

| **Predictor** | **Response** | **Moderator** | **Coefficient** | **T Statistic** | **Support** |
|---|---|---|---|---|---|
| Team Dispersion | Business Flexibility | Experience of working with multi-location teams | 3.862609 | 1.761764* | Supported |
| Workplace Mobility | Business Flexibility | Experience of similar project technology | 6.472321 | 1.793390* | Supported |
| Team Dispersion | Technological Flexibility | Experience of project of similar magnitude and complexity | 2.153359 | 2.951914*** | Supported |
| Team Dispersion | Business Flexibility | Experience of working with other team members | 1.852383 | 1.999618** | Supported |
| Team Dispersion | Technological Flexibility | Technology Infrastructure | – 7.343556 | 5.873837*** | *Not Supported* |
| Workplace Mobility | Business Flexibility | Technology Infrastructure | 4.306196 | 2.015885** | Supported |
| Workplace Mobility | Technological Flexibility | Technology Infrastructure | 4.321220 | 2.711087*** | Supported |
| Variety of Practices | Business Flexibility | Technology Infrastructure | – 4.378671 | 2.168730** | Supported |
| ***: p<0.01; **: p<0.05; *: p<0.1 | | | | | |

**Table 4: Significant Moderating effect results**

## DISCUSSION

It is interesting to see the effects of different dimensions of virtuality on business and technological flexibility. Where team dispersion positively and significantly affects both business and technological flexibility, workplace mobility has a significant negative impact on business flexibility. But as the overall effect is significant and positive we can safely assume that effect of team dispersion compensates for the negative effects of workplace mobility. This negative effect of workplace mobility on business flexibility may be caused by the increased coordination effort requirements. The effects of workplace mobility on technological flexibility, and that of variety of practices on business flexibility are not significant. Interestingly, though not included in the model, variety of practices has a significant and negative effect on technological flexibility.

Close examination of the moderating effects provides support for virtual team to have potential of providing sustained competitive advantage. 'Experience of working in multi-location teams' and the 'experience of working on projects employing similar technology' have strong moderating effects on the relationship between virtuality and flexibility. This underlines the role of history in the better performance of virtual teams. The capability and skill of making a virtual project team successful depends strongly on the earlier decisions taken by the firm of early adoption of virtual team work, and expertise gained by employees by working on similar technologies. Early adoption also means sufficient investments in the support structure for virtual work. This is again emphasized by the strong moderating effect of 'experience of project of similar magnitude and complexity'. All these together create a historical path that has to be followed by imitating firms to harness the potential and achieve success by creating virtual teams.

The support for the moderating effects of 'experience of team members of each other' argues in favor of virtuality to be socially complex resource. Experience of team members of each other grows over time. This familiarity creates bonds among team members that can not be imitated. Intuitively this should moderate the impact on flexibility. There is no ambiguity in the causal relationship here that more experience of team members of each other makes them work better and thus more flexible but this does not necessarily imply that when such experience is absent it can be created through systematic efforts (Dierickx and Cool 1989). It can be argued that the professional behavior overtakes the interpersonal behavior in case of short-term, project-specific virtual teams, but the overall outcome suggests that at the end of the day virtual work is a social phenomenon.

The technology infrastructure for virtual work is easily available in the market. But technology in itself is not a resource. Technology interacts with other firm resources and creates new networked resources that provide competitive advantage (Mata et al. 1995). Strong moderating effects demonstrated by technology infrastructure suggests that it's not just the presence of technology but the way it is put to use by the socially complex resources that provides the competitive advantage.

From results we see that though the main effect of team dispersion on business flexibility is positive and significant. The effect is strong enough to overcome the negative effects of workplace mobility on business flexibility, and variety of practices on technological flexibility. From this it can be interpreted that today's virtual teams in software development are still living under the shadow of software outsourcing, where having a few people onsite solves most of the problems. On the other hand, other significant main effects have mixed support for moderation by different experiences, technology infrastructure. In fact, technology infrastructure has a negative moderation between team dispersion and technological flexibility thus reducing its positive effects. Simultaneously, technology infrastructure negatively moderates the negative effect of variety of practices on business flexibility, thus reducing it. It is very difficult to argue for any one support for achieving flexibility by being virtual. This also makes replication of the impact difficult for competing firms. The impact of team dispersion on business flexibility has been relatively easily replicated by software outsourcing firms. It reduced the costs and provided access to larger talent pools. But the true impact of virtuality in improved business and technological flexibility is still elusive for many firms. This alludes to the presence of causal ambiguity of the linkage between virtuality and flexibility of incorporating environmental changes.

### Direction for future research

There are still a few questions left unanswered and unexplored in the study. What is the best path to achieve best results from virtuality? Under what conditions does virtual work break down? Is infinite virtuality desirable? If not, then what is the optimum level? We need to look deeper into the individual relations of different dimensions of virtuality and different types of flexibility. We have only explored business and technological changes and the flexibility associated with them. A large number of changes occur not outside the team but within. These may be due to attrition, or change in the ownership of the project, change in the way team is managed, or simply the team may have been reorganized. All these need to be explored further.

Task characteristics can have some impact on how the level of virtuality affects the flexibility of software development project teams. The impact may be different for routine tasks vis-à-vis tasks high on creativity. Task characteristics have not been included in the study for parsimony reasons. By focusing on software services project teams the differentiating effect of task characteristics is minimized.

Culture as a separate variable affecting flexibility has not been included in this study. The cultural aspects are subsumed in team dispersion, and variety of practices. Individual personal characteristics may also have an impact on virtual team effectiveness (Workman et al. 2003), but they have not been included in the present study.

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