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An Empirical Investigation into the Matching Problems among Game Theoretically Coordinating Parties in a Virtual Organization

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Abstract

Virtual organization emerged as a highly flexible structure in response to the rapidly changing environment of 20th century. This organization consists of independently working parties that combine their best possible resources to exploit the emerging market opportunities. There are no formal control and coordination mechanisms employed by the classical hierarchical structures. Parties, therefore, manage their dependencies on each other through mutual understanding and trust.

Mathematician John Nash, having significant contributions in Game Theory suggests that in every non-cooperative game there is at least one equilibrium point. At this point, according to him, every strategy of the player represents a response to the others' strategies. Such equilibria could exist in a virtual organization, at which parties coordinate with each other to optimize their performance.

Coordination/Matching problems are likely to arise among game theoretically coordinating parties in a virtual organization, mainly due to lack of binding agreements. By identifying and resolving these matching problems, virtual organizations could achieve efficiency and better coordination among parties.

Keywords - Virtual organization, Game theory, Matching problems, Coordination

1. Introduction

Organizational environment is rapidly changing toward increasing complexity and challenges. This change has first been recorded as 'environmental turbulence' by Emery and Trist in 1965. They contend that the environment in which organization exists is also changing at a rapid pace [12]. The effect is the emergence of new organizational forms capable of keeping pace with rapidly changing environment. These organizations have variously been described as modern and postmodern organization [5]; organization of the future [20] and the next generation enterprise [25]. Tremendous potential exists within these contemporary structures to respond to the market changes [47].

Within these contemporary structures, virtual organizations are considered as the most flexible arrangement of enterprise. Badrinarayanan and Arnett [2], present three major reasons of the emergence of virtual organization i.e. the development of flatter, decentralized and adaptive organizational structures; collaborations of geographically dispersed parties and advances in technology. These are the elements of virtual organizations which make them capable of competing with the market forces. Along with these elements, the importance of coordination and trust can never be ignored for parties in a virtual organization [30], [16]. According to Malone and Crowston

[30], 'coordination is managing dependencies between activities' (p.90). Trust, on the other hand, creates mutual understanding among parties which is necessary to ensure coordination.

Virtual organization has been the focus of many contemporary organizational development researchers. After the pioneering work of Davidow and Malone in 1992, several researchers have attempted to explore the concept from different perspectives. Virtual organization has been extensively studied for the use of information and communication technology, coordination and trust among parties, geographical location of parties and the networking of enterprises. One of the areas which is still lacking in literature is behavioral aspect of coordination. Therefore, specific mechanisms of coordination and the problems arising out of virtual coordination among parties offer significant potential for research. In an effort to explore this area, the problems of matching or coordination among game theoretically coordinating parties of virtual organizations have been identified by Yasir and Majid [47]. This was a pioneering research in several respects as it not only provided theoretical foundations for the study of game theoretic coordination in virtual organizations but also elucidated possible matching problems among parties.

Study of game theoretic relationship among organizations is not a new idea. Yasir and Majid [47] report that researchers as Schmidt and Kochan [36] have applied game theory to explore the relationship among organizations. This research, therefore, focuses merely upon the game theoretic relationship among parties in a virtual organization and matching problems arising thereof. It is based on prior conceptual study by the authors and provides empirical evidence of the matching problems among virtually coordinating parties.

The study of virtual organization reveals that it is a temporary grouping of parties to exploit the emerging market opportunities. The presence of flexible, non-enforceable agreements among parties and their independent moves toward a common goal suggest that their relationship could be modeled as a non-cooperative game. Nash equilibrium could exist among parties at which all the parties may operate at their optimum performance level to achieve common objectives. The results of this research reveal that matching problems arise during the relationship due to presence of multiple Nash equilibria, lack of harmony, and coordination among parties etc. These were predominantly attributable to the absence of formal control among parties.

This research empirically investigated the matching problems arising among game theoretically coordinating parties in a virtual organization. Data was collected using unstructured interviews and observation. Small and medium enterprise (SME) clusters in Pakistan which demonstrated considerable characteristics of virtual organization were the focus of this study. After a review of relevant literature, methodology for this study is presented which becomes the basis for the discussion on possible solutions for matching problems. Using the results of this research, parties in a virtual organization could manage to achieve their joint objectives more effectively. Moreover, the researchers can employ the discussion and results of this research for exploring new areas of game theory and virtual relationship among organizations.

2. Literature review

This section presents a discussion about key elements of virtual organization and identifies how game theory could be applied to study the coordination and matching problems among parties. A separate explanation of each of these concepts is as the following:

2.1. Virtual Organization

Virtual organization is considered as the most contemporary structure capable of competing with the turbulent environment of today. Although virtual relationship in some form existed among organizations of the past, the concept of virtual organization itself emerged only two decades ago [14]. Virtual organization is considered to have gained widespread acceptance due to the need for collaborative relationship among enterprises for sharing diverse technical and human resource skills [9], [46]. Researchers also present advancements in information and communication technology [24]; formation of geographically distributed work groups [10] and the need for a continuous

change and market orientation [1] as significant factors influencing the emergence of virtual organization.

Hence, the virtual organization could be defined as a group of independent parties, temporarily linking together by means of electronic communication and information technology to attain a common objective [9], [15], [21], [46]. Researchers [28] argue that these organizations use ICTs to work across space, time, and organizational boundaries. For the success of such geographically distributed organizations, development of trust among parties is essential [16]. Trust is a bond which keeps the independently working parties together, especially in the absence of any formal controls [4], [7], [22]. Thus, in the words of Harrington and Ruppel [17], “a virtual corporation is built on the core competencies, but it is cemented with trust” (p. 224).

Whereas trust is a bond which keeps the parties together in a virtual organization, coordination helps them in successfully managing their relationships [30]. Coordination has long been considered as a solution to problems arising from interdependence of organizational units; see for example [8]. Therefore, in the case of virtual organization where parties are strongly interdependent for the accomplishment of their tasks, coordination has particular significance [7], [30], [44]. Coordination in a virtual organization has been discussed by researchers with respect to the role of ICTs [11], [43]; trust [22] and geographical location [34] etc. Different mechanisms of coordination, therefore, have also been proposed to work with these elements of virtual organization.

Despite a good deal of work done in this discipline, the area which remained unexplored until the work of Yasir and Majid [47], is game theoretic coordination in a virtual organization. The research established theoretical foundations for game theoretic coordination and the associated matching problems in virtual organizations. Based on the arguments established in [47], in this research we are providing empirical analysis of matching problems among game theoretically coordinating parties in a virtual organization. Before entering the discussion of game theoretic coordination and matching problems, we are providing a brief introduction of game theory and its relationship with virtual organization.

2.2. Game Theory

Game theory is a branch of applied mathematics which in its present form has been presented by Neumann and Morgenstern [45]. It has diverse applications in various fields including economics and management. A game according to [40] is a situation in which parties interact and their outcomes depend on the strategies of each other. Thus game theory is the study of conflict and cooperation between parties.

Game theory has broadly been divided into two branches i.e. cooperative and non-cooperative games. The difference between these two lies in the presence or possibility of binding agreements between parties. Whereas, the cooperative games allow for communication and formation of binding agreements [38]; in non-cooperative games there are no such agreements among parties [3]. In the absence of binding agreements in non-cooperative games, [19] explains that players must agree on a stable and efficient equilibrium point. The presence of equilibrium points in a non-cooperative game was proved for the first time by John F. Nash [33] who called it a ‘Nash Equilibrium’. Although according to Nash [33] there could be more than one equilibria in a game, a stable and efficient equilibrium point provides maximum payoffs to all the players at a specific joint strategy. Therefore, at such an optimal equilibrium point according to Chamberlin [3], “no player can do better by unilaterally switching to another strategy” (p. 264). The following discussion provides an explanation of Nash equilibrium and game theoretic coordination in a virtual organization.

2.3. Game Theory and Virtual Organization

A review of literature on virtual organizations suggests that these are temporary combinations of geographically dispersed and independently working parties, coordinating with

each other using mechanisms of ICTs and trust. In a situation where no binding agreement exists among parties but they work independently for a common purpose, their relationship could be modeled in the form a non-cooperative Nash equilibrium.

Nash [33] states that in non-cooperative games players cannot form binding agreements thus they must agree on an equilibrium point which may satisfy the appropriate stability and efficiency requirements of a game [18]. At least one such equilibrium point exists in every finite non-cooperative game [33] and at an optimal Nash equilibrium “every player is playing a best reply to the behavior of the other players” [29, p.1348]. A recent study, [27] also presents optimal Nash equilibrium as a pair of strategies representing best response to each other and the players have no motivation to change their strategies.

In a virtual organization Nash equilibrium would be the optimal equilibrium point at which all the parties agree to accomplish their common objectives. Parties coordinate with each other at an optimum performance level because this helps them achieve the targets which are not individually achievable [9], [31]. With the parties organized at an optimal Nash equilibrium, coordination among them could be called as ‘Game Theoretic’. Empirical research on game theoretic coordination in a virtual organization suggests that it is different from coordination in classical organization. This difference exists because of the lack of formal controls and non-enforceability of agreements among parties.

In a virtual organization, parties freely choose the most suitable group members after considering all the potential matches (enterprises). This could be a representation of many-to-many stable matching [35]. The discussion on matching one kind of agent with another started with the work of Gale and Shapely [13]. They introduced two-sided matching models while focusing on the college admissions and marriages. According to [13], the matching problem was to make stable pairs in which agents on each side could find a match for themselves from the opposite side, for example, matching potential students with the colleges offering admissions, or matching men and women for a stable marriage. Later on, [39], and [23], applied two-sided matching models to the study of labor market and firms’ preferences. Szilagy and Schweiger [41] provided a framework for matching managers to strategies of organizations, while relatively recently, [26] discussed credible group stability in many-to-many matching problems, taking the case of UK hospital interns. The review of this literature reveals that substantial theory-based and empirical research exists on matching problems in the organizations but no research has specifically explored the matching problems arising out of a virtual relationship.

Due to the temporary and market-based nature of virtual organizations, it could be argued that the matching among parties in these organizations must be stable which ensures that the parties are matched with the most suitable counterparts. The relationship of trust and mutual understanding developed among parties in a virtual organization is also important to ensure a stable matching. It is only with a stable matching among parties that they could achieve the efficiency and effectiveness required for the success of a virtual organization.

However, it has been observed that due to the non-binding agreements and lack of formal control, matching or coordination problems [37] could arise among parties. Even with a stable matching of parties in a virtual organization, they could face challenges in organizing at an optimal Nash equilibrium; hence, matching problems are likely to arise. In [47] the possible matching problems that could arise out of game theoretic relationship have been explained. Here we are providing an empirical evidence of the existence of these problems with the help of a qualitative study of the virtual organization in Pakistan. Solutions to these problems as observed by the authors in the practice of enterprises forming a virtual relationship or proposed on the basis of the activities of enterprises have also been provided in the discussion section.

3. Methodology

The purpose of this study was to conduct an empirical investigation into the matching problems among game theoretically coordinating parties in a virtual organization. Therefore, the

focus of our research during the field data collection was specifically upon the matching problems arising out of a virtual relationship among enterprises. The matching problems identified in [47] were used for this research. For the purpose of collecting data, unstructured interviews of managers/owners and observation of the relevant manufacturing concerns were used. Responses/observation were recorded using diary method. The observation and interviews were conducted by the researchers themselves which left hardly any chance of ambiguity in recording.

In order to select a sample, the SMEs in the industrial clusters in Pakistan were studied for their nature and activities. After a detailed review, four industrial clusters were selected on the basis of the diversity in the nature of their activities and the presence of networking among enterprises in these clusters. These were the clusters of enterprises manufacturing readymade garments, surgical instruments, light engineering, and cutlery. In the next stage, a sample of 20 enterprises from each industrial cluster, that agreed to respond to the research, was drawn from among these four clusters of SMEs in Pakistan. Thus 80 enterprises in total were selected for this study. These clusters represented both the small and medium scale as well as low and high technology industries. The proportion of small and medium scale enterprises in each cluster is given out in Figure 1. The respondents in most of the cases were the owner managers but in some cases other officials having complete knowledge of the enterprise and its activities were interviewed with the permission of the top management. As the nature of goods manufactured was not important for this research, no distinction was made among them while recording the responses.

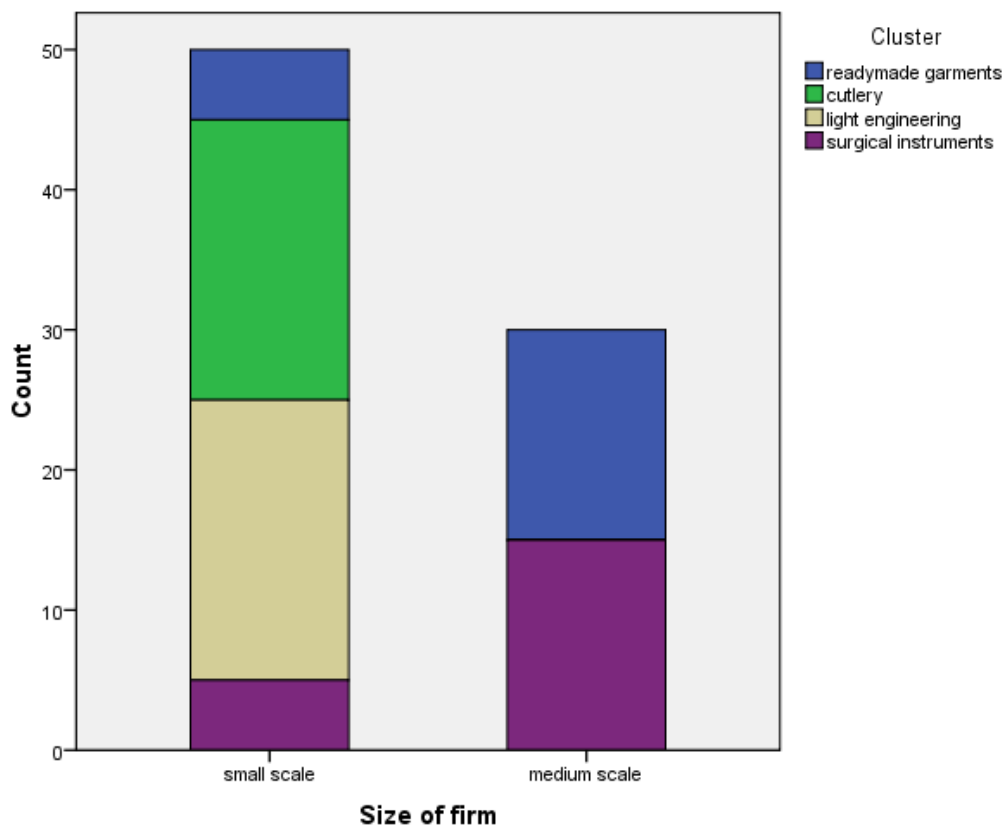


Figure 1: A description of the size of firms in each cluster

The matching problems arising among parties and the percentage of responses for either the agreement or disagreement with the existence of problem is recorded in the following table 1.

Table 1: Percentage response to the existence or non-existence of matching problems (N= 80)

Matching Problems	Agree %	Disagree %
Presence of multiple Nash equilibria	98.8	1.2
Lack of harmony between activities	43.8	56.2
Lack of common objectives of all parties	12.5	87.5
Problem of sharing resources	3.8	96.2
Problem of sharing responsibilities and division of labor	32.5	67.5
Sharing risk	51.2	48.8
Problem of establishing trust	2.5	97.5
Problem of maintaining control	72.5	27.5
Problem of timely response and completion of work	23.8	76.2
Problems in gaining competitive edge	85	15
Problems in capturing fads' market	66.2	33.8

4. Discussion

The results of interviews and observation of organizations for finding the possible matching problems suggest that for some of the problems there was almost complete agreement among parties that the problems exist while others showed mixed responses. For the presence of multiple Nash equilibria, 98.8 percent enterprises responded that the problem existed among virtually working parties. According to the respondents in these enterprises, the problem was solved by the information sharing and meetings in the beginning of a virtual relationship as well as at every step during the project.

About the issue of lack of harmony between activities, 43.8 percent agreed that the problem existed but 56.2 percent enterprises responded that creating harmony was not a problem due to the self-interest of all the parties involved in the activity. Those who responded positively toward the existence of problem were observed to have maintained a central coordinating body of all the members which had no power to enforce its decisions but worked to maintain harmony and establish coordination.

Strong disagreement was found for the existence of lack of common objectives and problems in sharing resources. Whereas, 12.5 percent enterprises agreed that the problem of lack of common objectives existed among parties, only 3.8 percent agreed to the existence of the problem of sharing resources. Major reason for a strong disagreement with the existence of these problems was found to be the geographical proximity of parties and the effect of social controls which prevented them from defection.

For the problem of sharing the responsibilities 32.5 percent agreed that this was a problem while working virtually. This problem used to be solved mostly with mutual agreement as there was no legally binding or written agreement among parties. Against it 51.2 percent enterprises responded that sharing risks was a problem. In many cases this problem resulted in the dissolution of virtual relationship due to the fragile nature of agreements among parties.

In an environment like Pakistan where business relationships mostly are based on trust 97.5 percent of enterprises appeared to have disagreed that establishing trust was a problem for them. On the other hand, even in this high trust environment maintaining control was found to be a serious problem where 72.5 percent enterprises reported that they found it difficult to maintain control while working in a virtual organization. All they could do to maintain a control was calling a joint meeting of central coordinating body to resolve the issues which was not effective in every case.

For the problem of timely response and completion of work, 76.2 percent disagreed that it was a problem. The reason of a timely response was that most of the parties coordinated because efficient and effective accomplishment of work was in their own interest. For the problems of gaining competitive edge and capturing fad's market 85 percent and 66.2 percent enterprises

responded respectively that those were serious problems. Reason of these problems was found to be the lack of advanced technical skills and resources.

5. Conclusion

The results of this research signify that there are several matching problems existing among game theoretically coordinating parties in a virtual organization. These problems are caused not only by the lack of binding agreements but also due to the need for technological advancement and skills enhancement of workers. By finding solutions to these matching problems, virtual organizations could gain efficiency and effectiveness required to remain competitive in the national as well as international markets. Moreover, the existence and extent of these matching problems in the real organizations could be studied and compared with the results of virtual organizations in the future endeavors of researchers.

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