Risk Assessment in the Formation of Virtual Enterprises

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Abstract. A Virtual Enterprise (VE) is considered as a temporary consortium of member enterprises formed to pool their core competencies and exploit the market opportunities. Although a VE has many phases, such as business opportunity identification, formation and partner selection, operation and dissolution. The partner selection phase is considered to be of the utmost importance and care should be taken to assess all the risk factors. This paper examines the partner selection problem by considering three types of risks, individual performance risk, collaborative performance risk and network risk. Based on the information provided by the potentially collaborating enterprises, a mathematical model has been developed for calculation of all three types of risks.

Keywords: Keywords: Virtual Enterprise (VE), risk analysis, partner selection, performance risk, network risk.

1 Introduction

With the introduction of a global economy and drift towards customized products, enterprises are seeking new paradigms, such as lean production, agile manufacturing, and virtual enterprises (VEs), to grasp market opportunities in a competitive global environment. A VE can be considered as a temporary coalition of globally distributed independent enterprises which share resources, skills, and costs, through the support of Information and Communication Technologies (ICT). A VE is formed when a market opportunity is realized and is dissolved when the opportunity or goal is achieved. In a VE, members of the alliance keep their own independent business processes and contribute their 'core competencies' in different complementary areas.

A VE operates in different phases as (1) opportunity identification, (2) VE formation and partner selection (3) operation and (4) dissolution. It is arguable, that of all the phases of a VE's lifecycle, partner selection is the most difficult task as it not only requires integration of core competencies but must also address different management styles and corporate cultures within the potential partners. A review of research literature reveals cases of the failure of VEs due to improper partner selection. According to [1] 60-70% of VEs are disbanded prematurely and identified trust, cultural differences, and different levels in the use of information as reasons for

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VE failure.

Although member enterprises of VEs, are capable of overcoming some of their individual limitations due to the advantages coming from being small (i.e they tend to be reactive, proactive and so forth), nonetheless collaborating within a VE brings a higher degree of risk than is experienced by individual enterprises. Due to such peculiarities, risk in VE formation requires a dedicated study.

In literature risk has been defined as ‘‘the variance of probability distribution of outcomes’’ [2]. The achievement of objectives realized by a VE depends on individual partners’ capabilities and their cooperative relationships. This produces the multi-dimensional risk associated with a VE and can negatively affect the desired outcomes of the VE. In an early study of risk factors, [3] defines risk as emerging from eight different perspectives. [4] studied the collaborative or network risk and divided the risk factors into performance and relational risks, where consideration of another dimension of risk, i.e. of accessing and managing risks rather than identifying them, [5] proposed a supply network risk tool to identify, assess and manage risk to support the single partner decision making process concerning network evaluation. According [6], when a network is chosen to run a business the consequent risk is higher than the risk related to the same business run by a single company. It is obvious from the findings of researchers that, although, return of investment, opportunities and risk sharing abilities are higher in VEs, they still operate in higher risky environments than single enterprises and therefore care must be taken in the formation (including partner selection) of VEs as it plays an important role in their success.

In the formation of a VE, the whole project is divided into subprojects and for each subproject a single enterprise is selected. In this study, the overall risk in the VE has been divided into three categories (as shown in figure 1) individual performance risk, collaborative performance risk and network risk.

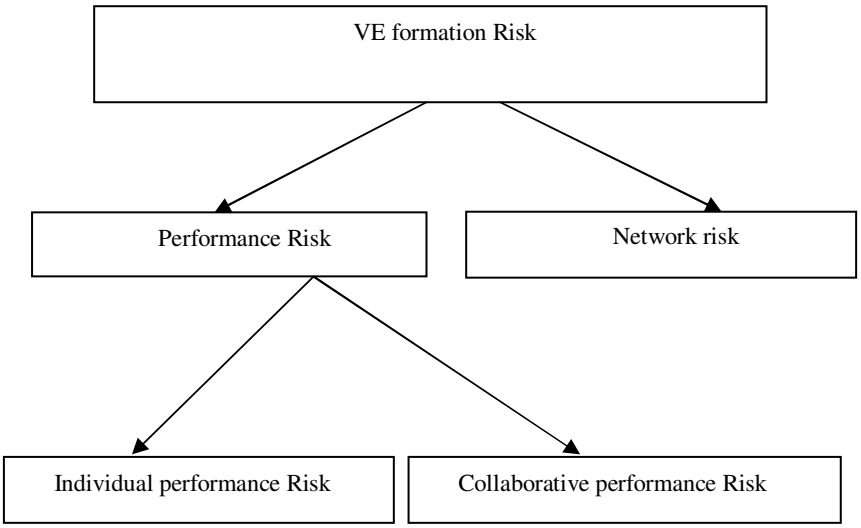

Fig. 1: VE formation risk

To clarify the proposed VE risk decomposition the overall risk can be considered as a combination of performance and network risk. Performance risk can be further subdivided into individual and collaborative performance. Individual risk is associated with and quality constraints. Collaborative risk is the measure of member enterprises' capability to undertake the project. Network risk is related to lack of trust, inaccurate information sharing and asymmetry in reciprocal position that hinders the effective collaboration [7].

This research aims to support risk management during the formation of VEs, firstly through the quantitative estimation of the overall risk and then through the evaluation of the overall risk associated cost. This approach will help decision makers to find the best possible consortium.

2 Quantitative Measure of the risk in the formation of a VE

The partner selection problem can be described as follows: A project **N** is divided into subprojects which are indexed n, $n \in \{1,2,....,N\} = \mathbf{N}$. m_i is the set of enterprises bidding for the subproject i, $i \in \mathbf{N}$. Every enterprise, bidding for the subproject provides information about its ability, capacity, technology, competency and other related information. Based on the information provided, individual performance risk is calculated, which is related to the enterprise's ability to finish the subproject, in terms of time, quantity, quality and other aspects. In most cases, with improper and incomplete information, individual risk can be given by interval values as: $[Lr_i^k, Ur_i^k]$, where L and U corresponds to the lower and upper limit of the individual performance risk associated with k^{th} enterprise and i^{th} subproject. Depending upon the optimism present in the partners this risk can vary between its lower and upper limit and can be taken as: $\mathbf{r}_i^k = \alpha Lr_i^k + (1-\alpha)Ur_i^k$, with $\alpha \in [0,1]$ defining the degree of optimism. Hence, a more optimistic network will have a lower risk value when compared to a pessimistic network.

The decision variable $x_i^k \in \{0,1\}$, determines the subproject and enterprise relation with respect to the constraint that a subproject cannot be awarded to more than one enterprise. If c_i is the cost of subproject *i,* then after considering the individual performance risk the estimated cost of the subproject will be: $E[c_i] = \sum_k (1 + \mathbf{r}_i^k x_i^k) c_i$

2.1 Collaborative performance risk

Collaborative performance risk analyses the risk level for each enterprise due to the presence of the other member enterprises in the VE. Based on the collaborative performance risk factor, an individual enterprise can decide whether to join the consortium. Collaborative performance risk ( ) can be calculated as:

$$\mathbf{R}_i^k = (1-\mathbf{r}_i^k) x_i^k [1 - \prod_{i' \neq i} \prod_{k' \neq k} (1-\mathbf{r}_{i'}^{k'}) x_{i'}^{k'}]$$

The first part of the formula calculates the probability that the k^{th} enterprise will be successful for i^{th} project (if assigned) and second part calculates the probability that at least one of the other subprojects will fail. The collaborative performance risk will increase the expected cost of the operation for each enterprise as the higher the risk in the environment, the higher will be the risk of return of investment. So now the cost of operation, considering the collaborative risk factor can be given as:

$$E'[c_i] = \sum_k [1 + (\mathbf{r}_i^k + \mathbf{R}_i^k) x_i^k] c_i$$

2.2 Network Risk

The first two types of risk, discussed above were related to individual risk factors and their consequences on the other partners. However, in a VE, where partners need to be seamlessly interoperable and cooperative, lack of communication, social, technological or cultural factors may hinder the desired output. This type of risk has been categorized as network risk in a VE, and this can be defined as: $nr_i^k = \sum_{k',k' \neq k} \sum_{i',i' \neq i} (\gamma^{kk'}/2) x_i^k x_{i'}^{k'}$ where $\gamma^{kk'}$ = risk of collaboration between two enterprises, with $\gamma^{kk'} \in [0,1]$ and $\gamma^{kk'} = 0$ if $k=k'$. In order to avoid double calculation we have divided the factor by 2.

The value of $\gamma^{kk'}$ will determine the affinity of collaboration between two enterprises (k and k') in the VE. If the value is closer to 0, higher will be the affinity of collaboration due to low risk factor.

The total network risk can be given as: $\mathbf{NR} = \sum_k \sum_i nr_i^k$

Mathematically, partner selection problem with risk analysis can be given as:

$$\text{Min} \sum_i E(c_i) + \{\sum_i c_i\} \mathbf{NR} \quad \textbf{(1)}$$

$$\text{Subject to} \sum_i \sum_k x_i^k = 1 \quad \textbf{(2)}$$

Equation (1) defines the objective function which minimizes the performance risk (first part) and network risk (second part). Constraint (2) determines that only one enterprise will be selected for each project.

3 Numerical Experiment

For numerical analysis, this paper considers a project which can be divided into four sub projects. The cost of each subproject is taken between 15,000 - 25,000. Three enterprises are bidding for the each subproject and their lower and upper limit for the individual performance risk are generated randomly between 0.1 and 0.2. The degree of optimism has been taken as 0.5 i.e. the mean of lower and upper value of the risk. Network risk between the enterprises is generated randomly between 0 to 1. The experiment result obtained has been shown in table 1. The first column in the table depicts the optimal network according to the all three risk factors taken separately and corresponding rows depicts the monetary value of the risk factor.

From Table 1 it is clear that the optimal network is not the optimal for any of the risk factors. In determining member enterprises for VE, this risk analysis will help in determining optimal network which will have lowest possible risk.

Table 1 : Cost associated with risk factors

Optimal Network	IR cost	CR cost	NR cost	TR cost
Individual risk(IR)	85500	38074	172500	296124
Collaborative risk (CR)	87350	33721	135000	256070
Network risk(NR)	88800	34095	120000	280395
Total risk (TR)	86100	34795	125000	245895

IR: Individual risk, CR: Collaborative risk, NR: Network risk, TR: Total risk

4 Conclusion

This paper considers the risk associated with the formation or partner selection of the virtual enterprise (VE). [8] had studied the performance and relational risk in the lieu of direct and indirect risk for the Network. However, individual risk and collaborative performance risk plays an important role along with network risk. As, the risk factors discussed in this paper not only help in forming optimal consortium for VE, but also provide useful information regarding risk and its associated cost for individual enterprises, which will help them in decision making regarding joining the consortium.

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