Summer May 31, 2013

Virtual Teams and its application in New Product Development, R&D and SMEs

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Virtual R&D Teams Definition

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The literature related to virtual R&D teams reveals a lack of depth in the definitions (Ale Ebrahim et al., 2010). Although virtual teamwork is a current topic in the literature concerning global organizations, it is problematic to define the meaning of 'virtual teams' across multiple institutional contexts (Chudoba et al., 2005). The concept of a "team" is described as a small number of people with complementary skills who are equally committed to a common purpose, goal, and working approach for which they hold themselves mutually accountable (Zenun et al., 2007). It is worth mentioning that virtual teams (VTs) are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). VTs work across boundaries of time and space using modern computer-driven technologies (Ebrahim et al., 2010). The term "VTs" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies". Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work, predominantly with electronic information and communication technologies (e-mail, video conferencing, telephone, etc.) (Hertel et al., 2005). From the perspective of Leenders et al. (2003), VTs are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Among the different definitions for virtual teams the following form is one of the most widely accepted definition: "VTs as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks"(Powell et al., 2004).
Therefore, a comprehensive definition of virtual teams may be taken as: *small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks (Ale Ebrahim et al., 2009).* Nowadays, this definition have gained popularity as found in Wikipedia (wikipedia, 2011). Virtual R&D team is a kind of virtual team that concentrate on the R&D tasks and projects (Ale Ebrahim et al., 2011).

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Critical factors for new product developments in SMEs virtual team

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2010

African Journal of Business Management Vol. 4(11), pp. 2247-2257, 4 September, 2010
Available online at http://www.academicjournals.org/AJBM
ISSN 1993-8233 ©2010 Academic Journals

Full Length Research Paper

Critical factors for new product developments in SMEs virtual team

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Accepted 15 July, 2010

Small and medium enterprises (SMEs) are considered as an engine for economic growth all over the world and especially for developing countries. During the past decade, new product development (NPD) has increasingly been recognized as a critical factor in ensuring the continued survival of SMEs. On the other hand, the rapid rate of market and technological changes has accelerated in the past decade, so this turbulent environment requires new methods and techniques to bring successful new products to the marketplace. Virtual team can be a solution to answer the requested demand. However, literature have shown no significant differences between traditional NPD and virtual NPD in general, whereas NPD in SME's virtual team has not been systematically investigated in developing countries. This paper aims to bridge this gap by first reviewing the NPD and its relationship with virtuality and then identifies the critical factors of NPD in virtual teams. The statistical method was utilized to perform the required analysis of data from the survey. The results were achieved through factor analysis at the perspective of NPD in some Malaysian and Iranian manufacturing firms (N = 191). The 20 new product development factors were grouped into five higher level constructs. It gives valuable insight and guidelines, which hopefully will help managers of firms in developing countries to consider the main factors in NPD.

Key words: Survey findings, new product development, factor analysis, virtual team.

NTRODUCTION

New product development (NPD) is widely recognized as an essential property of the firm (Lam et al., 2007). Life cycle of products is decreasing every year and the customer demand, on the other hand, increased dramatically. With the need to respond quickly to customer requirements, increased complexity of product design and rapidly changing technologies, selecting the right set of NPD is critical to long-term success of the firm (Chen et al., 2008). Obviously, due to SMEs limited technical and financial capability, the situation will be even more severe for small and medium enterprises (SMEs) than large organizations (Mi et al., 2006). However, virtuality has been presented as a solution for SMEs to increase their competitiveness (Pihkala et al., 1999). The creation of a virtual team is an opportunity to reduce the time in reduce the time in marketing the new products and respond quickly to market demands. May and Carter (2001) in their case study of a virtual team working in the European automotive industry have shown that increasing communication and collaboration between geographically distributed engineers, automaker and supplier sites, which make them get benefits are better quality, lower costs and reduce time to market (from 20 to 50%) for a new vehicle product.

The ultimate objective of all NPD teams is their superior marketplace success of the new product (Akgun et al., 2006). Specialized skills and talents required for the development of new products often lie (and develop) locally in pockets of excellence around the company or even worldwide. Therefore, companies have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). The successful NPD requires companies to develop routines and practices to collaborate with suppliers, customers and employees of the cross-functional internal (Mishra and

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Shah, 2009). Consequently, companies find that the internal development of all technologies necessary for new products and processes are difficult or impossible. They must increasingly acquire technology from external sources (Stock and Tatikonda, 2004). Virtualization in NDP has recently begun to make serious progress due to developments in technology-virtuality in NPD now is technically possible (Leenders et al., 2003). Virtual NPD in SMEs is in its infancy in developing countries, and little research has been done on the introduction of the NPD in SMEs through a virtual team. So, we formed the topic that is somewhat lacking in the literature as a research gap.

The main objective of this paper is to present a model of critical factors of NPD in small and medium enterprises in developing countries. The rest of the paper is organized as follows:

The main concepts of new product development; reviews recent study on the relationship between NPD and virtuality; explores the importance of SMEs; presents the relationship between SMEs and virtual team; describes the research methodology; presents data collection, data analysis and discussion; and finally, it concludes the paper with some perspectives.

WHAT IS NEW PRODUCT DEVELOPMENT (NPD)?

The literature provided a number of definitions for what constitute a new product development (NPD). Product development definition is used by different researchers in slightly different ways (Ale Ebrahim et al., 2009b). Generally, it is the process that covers product design, pro-duction system design, product introduction processes and start of production (Johansen, 2005). Loch and Kavadias (2008) in the “Handbook of New Product Development Management” define NPD to “consists of the activities of the firm that lead to a stream of new or changed product market offerings over time. This includes the generation of opportunities, their selection and transformation into artifacts (manufactured products) and activities (services) offered to customers and the institutionalization of improvements in the NPD activities themselves”. According to the product development and management association (PDMA) glossary for new product development in the PDMA tool book 3 for new product development (Griffin and Somermeyer, 2007), NPD was defined as “the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. Also, it is frequently referred to as product development”. Krishnan and Ulrich (2001) defined “product development as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale”. NPD has been described in a general form and there is no specified definition for new product development of SMEs virtual team in developing countries, which mean what is NPD, in SMEs virtual team, supposed to be in developing countries? This paper aims to extract the main factors of NPD in selective cases.

NPD AND VIRTUALITY

Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Badrinarayanan and Arnett, 2008). However, information technology (IT) improves NPD flexibility (Durmusoglu and Calantone, 2006). Ozer (2004) discussed that the internet facilitates and improves collaborations and thus increases the performance of new products. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams to develop new products is growing rapidly and can be dependent on organizations in maintaining a competitive advantage. On the other hand, competitive strategies are forcing companies to deploy their NPD resources globally, thus making collocated NPD teams prohibitively expensive and logistically difficult to manage (Susman et al., 2003). Susman et al. (2003) noted that research will increasingly focus on geographically dispersed NPD teams as their number will grow faster than collocated NPD teams. McDonough et al. (2001) argued that NPD teams are growing very fast, whereas virtuality affects the creative performance of NPD teams (Leenders et al., 2003). For example, Cisco has created the Cisco Collaboration Centre of Excellence to achieve its vision. Despite this industry attention, much is not yet understood about how to effectively collaborate virtuality to facilitate NPD (Susman and Majchrzak, 2003).

Some studies (Martinez-Sanchez et al., 2006) emphasized the challenges and difficulties experienced by virtual and conventional (for new product development) teams, which were not significantly different, although greater than the challenges and difficulties experienced by the in-house teams. NPD in SME’s virtual team has not been systematically investigated in literature. As a consequence, literature only, has not shown significant differences between traditional and virtual NPD in general. However, this paper aims to bridge this gap.

SMALL AND MEDIUM ENTERPRISES (SMES)

SMEs are a major part of the industrial economies (Eikebrokk and Olsen, 2007) and their survival and growth have therefore, being a prominent issue. The contributions of SMEs to employment and the countries’ gross domestic product (GDP) are highly significant

(Kotelnikov, 2007). Acs et al. (1997) argued that small firms are indeed the engines of global economic growth, whereas small and medium enterprises (SMEs) play an important role in promoting economic development. Many economists believe that the wealth of nations and the growth of their economies strongly depend on the performance of their SMEs (Schröder, 2006). In many developed and developing countries, small and medium-sized enterprises (SMEs) are the unsung heroes that bring stability to the national economy and help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003).

SMEs seem to be appropriate units when behaving like network nodes because of their lean structure, adaptability to market evolution, active involvement of versatile human resources, ability to establish a sub-contracting relation and good technological level of their products (Mezgar et al., 2000). In light of the above, SMEs have advantages in terms of flexibility, reaction time and innovation capacity that make them central actors in the new economy (Raymond and Croteau, 2006).

SMEs definition

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from country to country (O'Regan and Ghobadian, 2004). Table 1 illustrates a summary of SMEs definition in the manufacturing sector of selected countries. In most countries that are listed in Table 1, the definition is applicable to all sectors of the enterprises. Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition of SMEs (Deros et al., 2006). In the absence of a definitive classification, an agreement has developed around the European Commission (EC) criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria, employee numbers (up to 250 employees), turnover and balance sheet statistics (Tiwari and Buse, 2007). While turnover and balance sheet statistics are part of the criteria, the overriding consideration in practice appears to be an employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small firm than to the medium-sized firm. The case studies employed here are SMEs in the Malaysian and Iranian manufacturing sector, which are chosen according to the EC definition of SMEs (Figure 1).

SMEs and virtual team

Past literature often hypothesized that SMEs were not innovated formally in recognized ways, and that they made much more extensive use of external linkages (Laforet and Tann, 2006; Hoffman et al., 1998). However, the SME is not a scaled-down version of a large company. It has different characteristics that distinguish it from large corporations and can of course change across different countries and cultures. Moreover, they are generally independent, multi-tasking, cash-limited and based on personal relationships and informality, as well as being actively managed by the owners, highly personalized, largely local in their area of operation and largely dependent on internal sources to finance growth (Perrini et al., 2007). To survive in the global economy, SMEs have to improve their products and processes by exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). So if small firms want to make a step change in their technological and innovational base, they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to focus on core competencies for efficiency matters; however, they need to cooperate with external partners to compensate for other competencies and resources. This is especially the case in the field of new product development, where SMEs face specific problems in comparison to large firms (Pullen et al., 2008).

Despite the widespread publicity of information technology, the application of internet technology to upgrade and enhance the product design and business operation by most enterprises, especially for the small and medium sized enterprises, is still at its infancy (Zhan et al., 2003). The SMEs are one of the sectors that have a strong potential to benefit from advances in information and communication technologies (ICTs) and the adaptation of new business modes of operation (Miles et al., 2000). The use of ICTs can be considered as key factors for innovation and entrepreneurship; however, it is a must for SMEs to innovate ICTs (Redoli et al., 2008). More so, It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). Collaboration is particularly critical when SMEs are involved with the aim of developing new products (Romero et al., 2008).

The success of developed countries can be attributed to factors relating to the emergence of new business technologies and cultures, such as virtual technology. This constituted the soft-technology complex that provided the environment for innovation and the effective application of technologies (Zhouying, 2005). Developing countries are, on the other hand, characterized by the absence of soft technology and limited abilities to make effective and efficient use of the technologies they obtain through a variety of transfer mechanisms, and to innovate and compete in the global market. Many SMEs have difficulties achieving successful innovation, despite having significant investment in research and development (O'Regan et al., 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible

Table 1. Definition of SMEs in the manufacturing sector of selected countries (Adopted from Ale Ebrahim et al., 2009a).

Country	Category of enterprise	Number of employee	Turnover	Other measure
European Commission (EC) criteria	Small	10 - 50	Less than € 10 (13.5 USD) million turnover	Balance sheet total: Less than € 10 (13.5 USD) million balance sheet total
European Commission (EC) criteria	Medium	Fewer than 250	Less than € 50 (67.6 USD) million turnover	Balance sheet total: Less than € 43 (58.2 USD) million balance sheet total
Indonesia	Small	5 – 19		Annual value of sales of a maximum of IDR1 billion (110,000 USD)
Indonesia	Medium	20 – 99		Annual value of sales of more than IDR1 billion, but less than IDR50 billion (5.5 million USD)
Iran	Small	Less than 10* Less than 50**		
Iran	Medium	10 - 100* 50 - 250**		
Japan		Less than 300		¥100 (1.1 USD) million assets
South Korea		Less than 300		
Malaysia	Small	5 to 50	Between RM 250,000 (75,000 USD) and less than RM 10 (3 USD) million	
Malaysia	Medium	50 to 150	Between RM 10 (3 USD) million and RM 25 (7.5 USD) million	
Philippines	Small	10 - 99		Between PHP 3 - 15 million (66,000 -330,000 USD) asset
Philippines	Medium	100 - 199		Between PHP 15 - 100 million (330,000 - 2.2 million USD) asset

*USD selected as a reference currency and the conversion is approximate.

assets, but more in those areas that will directly generate their future competitive advantage (for example, in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in already existing technologies). Moreover, the web-because of its easy access to large numbers of potential customers at reasonable cost may especially aid smaller companies that have not enjoyed the same national reach or financial resources as larger companies for market research (Buyukozkan et al., 2007). Levy et al. (2003) state that SMEs are knowledge creators but are poor in knowledge retention. They need to be proactive in knowledge sharing

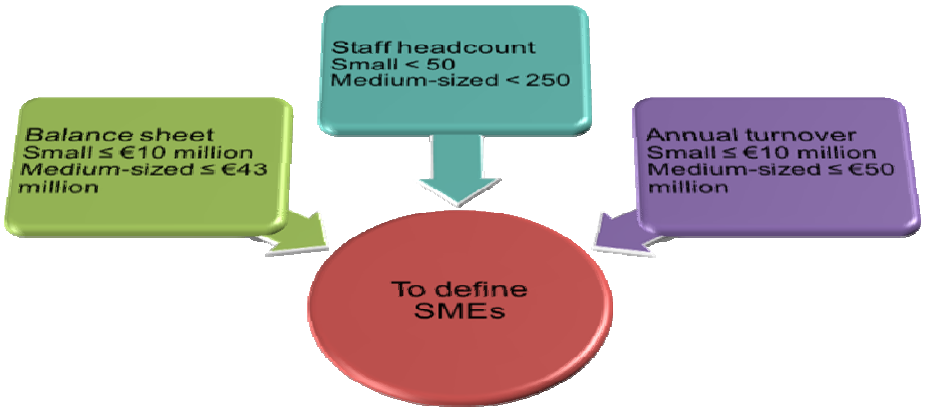

Figure 1. European Commission (EC) criteria for classification of SME (used in this research).

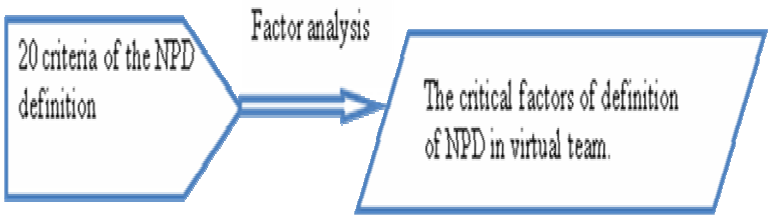

Figure 2. Research framework.

knowledge sharing arrangements in order to recognize that knowledge has value and that the value added is derived from knowledge exchange (Egbu et al., 2005).

RESEARCH METHODOLOGY

This research applied a statistical approach based on factor analysis and research framework (Figure 2). Factor analysis is a technique that attempts to identify underlying variables or factors that explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance that is observed in a much larger number of manifest variables. It is also suitable for analyzing the patterns of complex, multidimensional relationships encountered by researchers (Fathian et al., 2008).

Based on the main factors in NPD, 20 questions were derived from the literature review and an online questionnaire was designed. To help disentangle the concepts of new product development in the virtual team of SMEs, 20 individual criteria were asked from respondents (Table 2). These criteria have been grouped together through factor analysis to form the critical factors of NPD in virtual teams. The respondent asked a series of questions such as NPD 1: “Based on your organizations, is a new product/process development the use of things already known (reverse Engineering)? “

Data collection

The research target was manufacturing SMEs in Malaysia (M) and Iran (I) that are using the virtual team in their organization. In order to understand the viewpoints of SMEs on NPD, an online questionnaire has been sent to relevant SMEs in both countries. The rapid expansion of internet users has given web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002). Denscombe (2006) findings encourage social researchers to use web-based questionnaires with confidence, and the data produced by web-based questionnaires are equivalent to that produced by paper-based questionnaires. Other authors emphasized that the data provided by the internet methods are, at least, of good quality as those provided by traditional paper-and-pencil methods (Deutskens et al., 2006). However, minor differences occur between the two survey methods. Online respondents provided more improvement suggestions (Deutskens et al., 2006) which tended to be slightly longer than those from the paper version. As a result, the differences are not statistically significant (Denscombe, 2008).

The main sampling target was the managing director, R&D manager, the new product development manager, project and design manager and appropriate people who were most familiar with the NPD in the firm. For better understanding, the questionnaire has been prepared into different languages, that is, English and Persian. Consequently, the Iranian respondents could select either English or Persian version of the questionnaire. A total number of 3,625 e-mails have been sent to relevant SMEs and 686 of them clicked the online web page and answered the questionnaire. Out of 686 respondents, 190 SMEs responded completely and the rest answered partially. Table 3 summarized the online survey data collection. Only 121 firms met the criteria of SMEs definition in this research, so the rest of the respondents deducted from the factor analysis. A cross-tabulation descriptive statistics was employed to find the frequency and relationship between the country and

Table 2. Criteria (20) of the NPD.

Question	Criteria
NPD1	The entire R&D activities
NPD2	The use of things already known (Reverse Engineering)
NPD3	Making use of existing technologies (Adaptation)
NPD4	Increase efficiency of product
NPD5	Meet the role and regulation
NPD6	Improvement in product functionality/quality
NPD7	Improvements in elements of product technologies
NPD8	Major innovation in product technologies
NPD9	Major innovation in products as a whole
NPD10	Creation of new product concepts
NPD11	Improvement in the product process
NPD12	Reduction in quality problems
NPD13	Surprise or delight customers
NPD14	Replacing products that are phased out
NPD15	Extending product range
NPD16	Reducing production lead times
NPD17	Gaining new markets or market share
NPD18	Reducing labour costs
NPD19	Reducing material consumption
NPD20	Reducing energy consumption

Table 3. Summarized online survey data collection.

Numbers of e-mails sent to Malaysian (M) SMEs	Numbers of e-mails sent to Iranian (I) SMEs	Total e-mails sent to SMEs	Total responses (click the online web page)	Total responses/ sent (%)	Total completed	Total completed/ sent (%))	Total completed/ received (%)
2068	1557	3625	686	18.9	190	5.2	27.7

virtuality as illustrated in Table 4.

Data analysis

In the case of reliability analysis, Cronbach's (1951) alpha was employed to measure the internal consistency of the 20 factors. A reliability test was carried out to ensure that the research finding have the ability to provide consistent results. Cronbach's alpha for the 20 NPD factors was found within acceptable limits and was found to be 0.926, which means that there was a high reliability for the designed questions. In order to conclude whether the partial correlation of variables was small, the authors used the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Chi-square test of sphericity (Fathian et al., 2008). Table 5 summarized the results of KMO, which is 0.863 and the significant value of Bartlett's test in less than 0.05, which

Table 4. Cross-tabulation between country and virtuality.

			Virtuality NPD		Total
			Yes	No	
Country	Iran	Count	50	18	68
		% within country	73.5	26.5	100.0
	Malaysia	Count	19	34	53
		% within country	35.8	64.2	100.0
Total		Count	69	52	121
		% within country	57.0	43.0	100.0

Table 5. KMO and Bartlett's test results.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.863
Bartlett's test of sphericity	Approx. chi-square	961.993
	df	190
	Sig.	0.000

means there was a good correlation.

An exploratory factor analysis was conducted on 20 NPD factors using a principle component analysis with a varimax rotation and an Eigenvalue of 1 as the cut-off point (Akgün et al., 2008) and an absolute value of a factor loading that is greater than 0.5 (Fathian et al., 2008). The items and their factor loadings, after exploratory factor analysis, Eigenvalue and percentage of variance explained, appear in Tables 6 and 7. The 20 factors were grouped into five higher level constructs, which had an Eigenvalue greater than one.

DISCUSSION

The authors attempted to identify and named the confirmed factors based on the principle of being concise without losing clarity of meaning. After extracting the higher level constructs, variables with higher loadings are considered more important and have greater influence on the name of selected reduced factors. The names and contents of five derived factors are discussed.

Factor 1

It consists of NPD 17 to 20, which are “gaining new markets or market share“, “reducing labor costs”, “reducing materials consumption” and “reducing energy consumption”, respectively. This factor is named “process features”.

Factor 2

It consists of NPD 4, 5, 12 and 13, which are “increase efficiency of product”, “meet the role and regulation”, “reduction in quality problems” and “surprise or delight customers”, respectively. Since NPD 12 has higher loading (0.794), this factor was named “customer demand“.

Factor 3

It consists of NPD 2, 3, 7 and 15, which are “the use of things already known (reverse Engineering)”, “making use of existing technologies (adaptation)”, “improvements in elements of product technologies” and “extending product range”, respectively. This factor is named “technology features”.

Factor 4

It consists of NPD 6, 8, 10 and 11, which are “improvement in product functionality/quality”, “major innovation in product technologies”, “creation of new product concepts” and “improvement in the product process”, respectively. This factor is named “innovative process”.

Factor 5

It consists of NPD 1, 9, 14 and 16, which are “the entire R&D activities”, “major innovation in products as a whole”,

Table 6. Factor analysis results.

Component	Initial Eigen values			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	9.683	48.417	48.417	3.370	16.851	16.851
2	1.643	8.214	56.631	3.022	15.108	31.959
3	1.202	6.011	62.641	3.012	15.058	47.017
4	1.112	5.558	68.200	2.934	14.670	61.687
5	1.000	5.001	73.201	2.303	11.514	73.201
6	0.812	4.061	77.262			
7	0.767	3.837	81.099			
8	0.605	3.026	84.125			
9	0.546	2.729	86.854			
10	0.465	2.324	89.178			
11	0.400	1.998	91.176			
12	0.342	1.712	92.888			
13	0.322	1.609	94.497			
14	0.229	1.145	95.642			
15	0.225	1.123	96.764			
16	0.212	1.061	97.826			
17	0.149	0.746	98.572			
18	0.108	0.538	99.110			
19	0.091	0.455	99.565			
20	0.087	0.435	100.000			

Extraction method: Principal component analysis.

Table 7. Rotated component matrix sorted by size.

	Component (Cronbach's alpha) t				
	1 (.850)	2 (.821)	3 (.749)	4 (.790)	5 (.735)
NPD19	0.792	0.134	0.248	0.218	0.019
NPD18	0.762	0.287	0.232	0.103	0.227
NPD20	0.715	0.250	0.325	0.142	0.135
NPD17	0.515	0.364	-0.052	0.282	0.343
NPD12	0.278	0.794	0.313	0.155	0.203
NPD4	0.238	0.784	0.135	-0.288	0.069
NPD5	0.203	0.754	0.345	0.105	0.237
NPD13	0.379	0.462	0.280	0.275	0.453
NPD7	0.144	0.141	0.721	0.512	0.089
NPD2	0.372	0.218	0.706	0.148	-0.002
NPD3	0.169	0.258	0.670	0.165	0.219
NPD15	0.130	0.296	0.653	0.220	0.457
NPD10	0.149	-0.059	0.322	0.721	0.228
NPD8	0.186	0.205	0.332	0.710	0.040
NPD6	0.206	0.393	0.136	0.668	0.041
NPD11	0.528	0.308	-0.016	0.580	0.171
NPD14	0.126	0.117	0.542	0.267	0.649
NPD9	-0.016	0.237	0.180	0.546	0.604
NPD16	0.569	0.034	0.090	0.170	0.591
NPD1	0.380	0.335	0.114	-0.133	0.569

Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser Normalization.

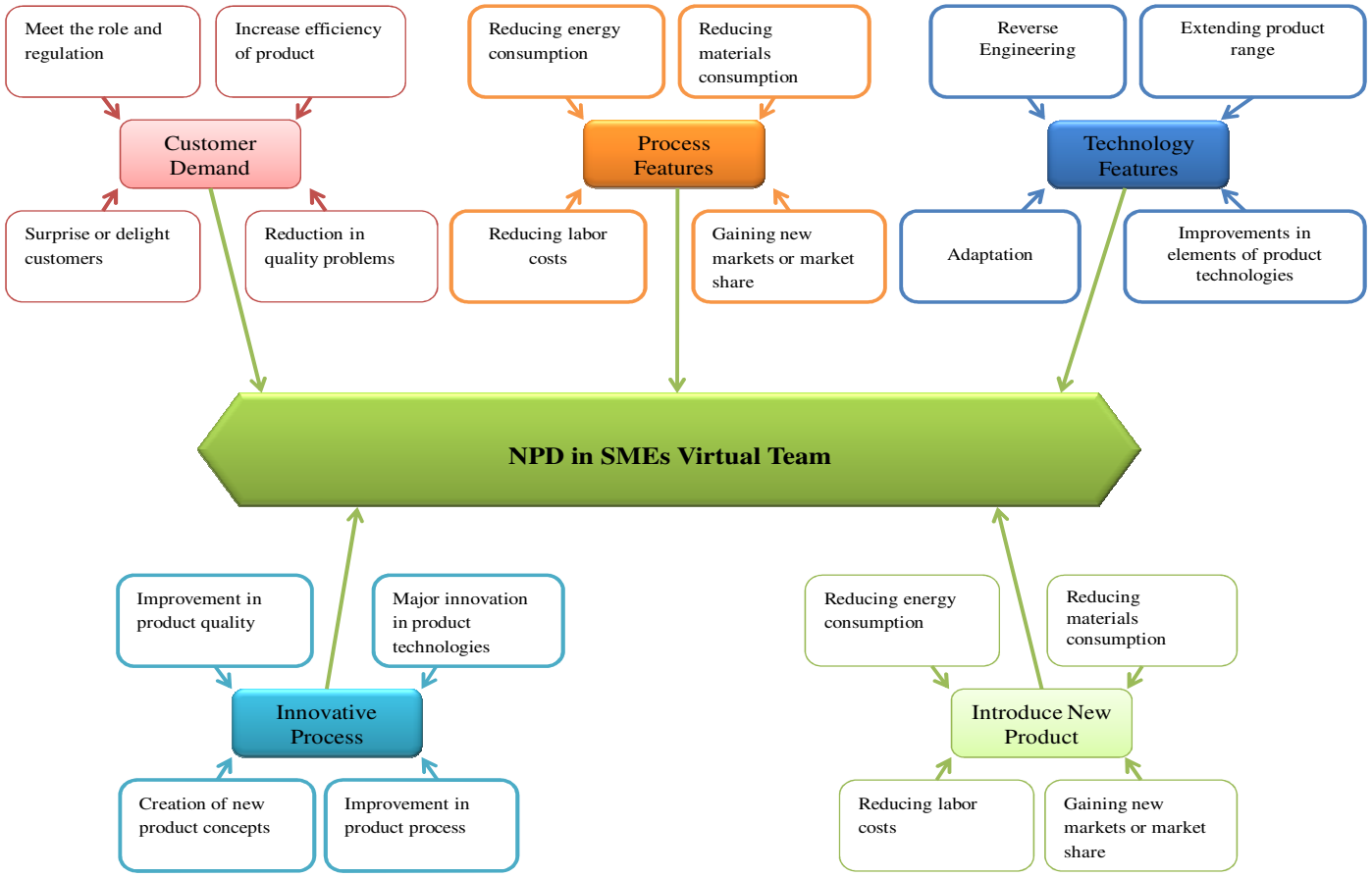

Figure 3. A conceptual model of NPD in SMEs virtual team (based on research results).

"replacing products that are being phased out" and "reducing production lead times", respectively. Since NPD 14 has been a higher loading (0.649), this factor was named "introduce new product".

All the aforementioned factors are summarized in Figure 3. This new conceptual model is based on data analysis of the survey findings. The conceptual model provides an overview of NPD understanding in SMEs (the ones which are familiar with virtuality) of some selected developing countries. Although more than half of the respondents are working on virtual team bases for new product developments, the virtual team application in SMEs is still in infancy. Slightly, more than 80% of the SMEs have not received an e-mail invitation to participate in an online survey (Table 3).

SMEs, especially in developing countries, severe from the lack of resources and manpower (Ale Ebrahim et al., 2009a) and as a result, the ability to consistently select the best factors to investigate, is therefore, vitally important to firms in the said countries. Hence, the manager of NPD team in SMEs has to optimize the new product process. This new conceptual model works as a tool to help a manager of the NPD team to focus on the major and important issues in NPD process, which lead to an increase in the efficiency of the procedure for new products. For academic researchers, this study contributes to a theoretical understanding of the factors that promote the diffusion of NPD in SMEs.

Conclusion

Factor analysis provides direct insight into the interrelationships between 20 variables and reduced it to five components. The first factor which is "process features" and which is a combination of "gaining new markets or market share", "reducing labour costs", "reducing materials consumption" and "reducing energy consumption", is more important than the rest four factors. So managers of firms in developing countries should consider the main factors in NPD. Customers demand (people) and technology features are respectively important after process issues. Therefore, going along with

Ebrahim et al. (2009c) recent research, people and process are more important in the virtual team than about technology.

Table 3 shows slightly, that above 18% of SMEs have received the online survey e-mail invitation. So it can conclude that most SMEs in the selected developing countries are still developing a new product in the traditional way, and they are not adopted with new information and communication technologies. As virtual NPD in SMEs is in its infancy in developing countries, it seems to be a necessary start for the introduction of the virtual team in the SMEs. The first step is perceived as NPD in this new environment, which is explored in this study.

This study is probably the first to present a conceptual model for the NPD issue in SMEs of the selected developing countries. The future research needs to investigate the model and verify it by a larger sample of SMEs from different sectors, since this study was limited to the manufacturing sector. In a larger sample, it is possible to compare the results between Iran and Malaysian SMEs.

ACKNOWLEDGEMENTS

This research was funded by a grant from the University of Malaya (Grant No. PS404/2009C) and the authors acknowledge this support. In addition, the authors are grateful to the editors and two anonymous reviewers for their helpful and insightful contributions on the first version of this document.

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Virtual R&D teams and SMEs growth: A comparative study between Iranian and Malaysian SMEs

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01. July 2010

African Journal of Business Management Vol. 4(11), pp. 2368-2379, 4 September, 2010
Available online at http://www.academicjournals.org/AJBM
ISSN 1993-8233 ©2010 Academic Journals

Full Length Research Paper

Virtual R&D teams and SMEs growth: A comparative study between Iranian and Malaysian SMEs

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Accepted 13 July, 2010

This paper explores potential advantages of using virtual teams for small and medium-sized enterprises (SMEs) with a comprehensive review on various aspects of virtual teams. Based on the standing of the pertinent literatures, attempt has been made to study the aspects by online survey method in Iran and Malaysia. In both countries, SMEs play an important role in their economies, employments, and capacity building. Virtual R&D team can be one of the means to increase SMEs efficiency and competitiveness in their local as well as global markets. In this context, surveys have been conducted to evaluate the effects of virtuality to the growth of SMEs. The study addresses some differences between two countries in engaging virtual research and development (R&D) teams in their SMEs. It is observed that there is a significant difference between the SMEs turnover that employed virtual team and that did not employ the virtual team. The way for further studies and recommend improvements are proposed.

Key words: Virtual R&D team, small and medium enterprises, survey, developing countries.

INTRODUCTION

Faced with the challenges like increased globalization of markets and technological change, SMEs need reinforced support through transnational research cooperation to enhance their innovation and research investment. SMEs' survival depends on their capability to improve their performance and produce products that could meet international standards (Gomez and Simpson, 2007). In other words, a certain level of competitiveness appears to be a prerequisite for an SME's survival when dealing with dynamic conditions in the business environment. To compete with global competition and, overcome the rapid technology change and product variety proliferation in the new manufacturing environment, SMEs must be able to sustain product innovation (Laforet, 2007). Internationalization holds much potential for the growth of SMEs (Lu and Beamish, 2006). One very important trend to enable new knowledge creation and transfer in-and-to SME's is the development of collaborative environments and networks to increase their innovation capabilities as a single unit and also the and also the capabilities of the network as a whole (Flores, 2006). Participation in networks has nowadays become very important for any organization that strives to achieve a differentiated competitive advantage, especially if the company is small or medium sized (Camarinha-Matos et al., 2009). E-collaboration is related to better operational and business performance (Rosenzweig, 2009).

O'Regan et al. (2006a) investigated in a sample of 207 manufacturing SMEs and found a positive correlation between R&D investment and technological change in products and processes in firms with static or declining sales. Kuo and Li (2003) argue that the empirical result in Taiwan's SMEs indicates that a firm's likelihood in undertaking foreign direct investment (FDI) reaches a maximum when its R&D intensity reaches 11.08%; hence a strong quadratic relationship between R&D intensity in SMEs and FDI exists. O'Regan et al. (2006a), after discussions with Managing Directors of six organizations suggested that, in general, investment in R&D for development of a number of new products introduced the need to meet technological changes in both processes and products and the importance of prototype development are the most important attributes of innovation in manufacturing SMEs. Gassmann and Keupp (2007) found

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that managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage (e.g., in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in already existing technologies).

Global market requires short product development times, and so SMEs are also forced into transition from sequential to concurrent product development (Kusar et al., 2004). SMEs are key actors in the innovation system and the economy of a country. Despite their limitations in size, they make a lot of creativity in products and services they provide through R&D. Therefore, networking seems to be one of strategic solutions for technology based companies in order to give them a competitive advantage and the ability to tap into the knowledge base of other network partners. Putting an SME in the way to Information Society or in the way to making the best ICT investment in terms of economic return through company benefits is more of an art than engineering (Redoli et al., 2008). Lawson et al. (2006) study focuses on R&D in SMEs, and consequently provides novel insights currently lacking in the published literature.

The first step of this paper provides a primary definition of virtual teams; the importance of SMEs, the major characteristics of SMEs, differences in R&D between SMEs and large firms, SMEs and virtual teams working, based on comprehensive literature review of recent articles. On the next step, after over viewing of SMEs in Iran and Malaysia, research hypothesis, methodology and data collection, survey results are described. Lastly a guide line for future study evolved. It is argued that the establishing of virtual teams should be given consideration in the management of SMEs. Although computers widespread use for personal applications, very few programming frameworks exist for creating synchronous collaborative applications between SMEs.

Virtual teams

A virtual team is a temporary group of professionals that work together towards a common goal such as realizing a new product, a joint project etc., and that uses computer networks as their main interaction environment (Camarinha-Matos et al., 2009). It is a worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Virtual teams comprised members who are located in more than one physical location. This team trait has fostered the extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007). Gassmann and Von Zedtwitz (Gassmann and Von Zedtwitz, 2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies, e-mail, video-conferencing, telephone, etc. (Hertel et al., 2005). Different authors have identified diverse areas. From the perspective of Leenders et al. (2003) virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organizations. Lurey and Raisinghani (2001) defined virtual teams - groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries. Amongst the different definitions of a virtual team the following concept from which the term employed in this paper is one of the most widely accepted definitions: (Powell et al., 2004), ''virtual teams are groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks ''.

SMEs definition

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from country to country (O'Regan and Ghobadian, 2004). Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition for SMEs (Deros et al., 2006). Table 1 illustrates the definition of SMEs in selected countries. In absence of a definitive classification, a consensus has been developed around the EC criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria (employee numbers (up to 250 employees), turnover and balance sheet statistics) (Tiwari and Buse, 2007). While turnover and balance sheet statistics are parts of the criteria, the overriding consideration in practice appears to be employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small to medium-sized firm. This study use Malaysian SME definition which is more limited than Iranian ones.

The importance of SMEs

The importance of small and medium-sized enterprises (SMEs) in economic growth has made them central elements in recent policymaking (Hoffman et al., 1998). SMEs are a major part of the industrial economies (Robles-Estrada and Gómez-Suárez, 2007; Eikebrokk and Olsen, 2007). Their survival and growth has therefore been a prominent issue. Beck et al. (2005) explored the relationship between the relative size of the small and medium enterprise (SME) sector, economic growth, and poverty alleviation using a sample of 45 countries, and found a strong, positive association between the importance of SMEs and GDP per capita growth. SMEs can successfully enter the global market if they can fulfill the customer needs regarding features and quality of products (Kusar et al., 2004). Acs et al. (1997) argued that small firms are indeed the engines of global economic growth. SMEs play an important role to promote economic development. SMEs in the beginning of R&D activities always face capital shortage and need technological assistance. In most countries, SMEs dominate the industrial and commercial infrastructure (Deros et al., 2006). More importantly SMEs play an important role in foreign direct investment (FDI) (Kuo and Li, 2003). Many economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance (Schröder, 2006). In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003). China's recent rapid growth is also linked to the emergence of many new small firms in village townships and in coastal areas, often in new industries (Acs et al., 1997).

SMEs seem to be appropriate units to behave like network nodes because of their lean structure, adaptability to market evolution, active involvement of versatile human resources, ability to establish sub-contracting relations and good technological level of their products (Mezgar et al., 2000). In the light of the above, SMEs have advantages in terms of flexibility, reaction time, and innovation capacity that make them central actors in the new economy (Raymond and Croteau, 2006). Gassmann and Von Zedtwitz (2003) based on 204 interviews with R&D directors and project managers in 37 technology-intensive multinational companies have shown five trends in organizing virtual R&D teams which are :

1. Continued internationalization of R&D will further increase the importance of and reliance on virtual R&D teams.
2. Virtual R&D teams will better integrate talent in newly industrialized countries.
1. Advances in information and communication technologies will further enhance the functionality of virtual teams.
2. Relative costs of running virtual R&D projects will decrease due to learning curve effects.
3. Highly decentralized virtual R&D teams will gain importance in open system architectures such as internet-based applications.

Susman et al. (2003) have probed more deeply than existing theories into the psychological and social dynamics of virtual teams and propose a model that articulates the processes that intervene between recognition of a misalignment, and appropriations that reduce or eliminate them. From the human resources point of view, SMEs' employees are given the authority and responsibility in their own work areas that can create cohesion and enhance common purposes amongst the workforce to ensure that a job is well done (Deros et al., 2006). In order to implement an appropriate knowledge management strategy in SMEs, cultural, behavioral, and organizational issues need to be tackled before even considering technical issues (Nunes et al., 2006). Acs et al. (1997) further argue that the international diffusion of SMEs innovations are important for global economic welfare. The traditional independence of small firms is being replaced by a network environment (Hanna and Walsh, 2002). Generally speaking three types of technologies are picked up by SMEs: small scale technologies, labor intensive technologies and specialized high technology know-how (Acs and Preston, 1997). Creating networks in the cycle of the management of these technologies is of a high importance.

The major characteristics of SMEs

In order to have a better understanding of SMEs, a brief knowledge of the characteristics of SMEs is a must. The major characteristics of SMEs are listed in Tables 2 and 3.

Dickson and Hadjimanolis (1998) state that since small companies typically lack some of the essential resources for innovation they have to acquire them from external sources, such as other companies, technical institutions, etc. Therefore, the management of inter-organizational relationships and networking in general may well be critical for the successful development in small companies. It is also important that the companies have the ability to network. As firms become 'networked' the critical capabilities are moving from within to between firms, and innovation will need to move too (Hanna and Walsh, 2002). Cooperative R&D is a useful way to overcome the lack of internal business resources and to improve innovativeness and competitiveness, particularly SMEs (Okamuro, 2007).

Table 1. Definition of SMEs in selected countries (adapted from Ale Ebrahim et al., 2009).

Country	Category of enterprise	Employee numbers	Turnover	Other measures
European Commission	Small	10-50 employees	Less than € 10 (13.5 USD) million turnover	Balance sheet total : Less than € 10 million balance sheet total
	Medium	Fewer than 250 employees	Less than € 50 (67.6 USD) million turnover	Balance sheet total : Less than € 43 million balance sheet total
Iran	Small	Less than 10* Less than 50**		
	Medium	10-100* 50-250**		
Malaysia	Small	Between 5-50 employees	Between RM 250,000 (75,000 USD) and less than RM 10 (3 USD) million	
	Medium	Between 50-150 employees	Between RM 10 (3 USD) million and RM 25 (7.5 USD) million	

*(CBI, 2009); **(ISIPO, 2009).

Table 2. Some of the major advantages of SMEs.

Advantage	Reference
Generally dominated by the entrepreneur (owner-manager)	(Jones and Macpherson, 2006; Bougrain and Haudeville, 2002; Love and Irani, 2004)
Able to respond quickly to customer requests and market changes, Customers focused	(Jones and Macpherson, 2006; Canavesio and Martinez, 2007; Huang et al., 2004)
Flexible and fast-response to change, easily adaptive to new market conditions , dynamic in behavior, developing customized solutions for partners and customers	(Deros et al., 2006; Sarosa, 2007; Abdul-Nour et al., 1999).
Concentrated production and sales in their home country	(Narula, 2004; Perrini et al., 2007).
Driven by client demands	(Lawson et al., 2006; Deros et al., 2006; Axelson, 2005)
Quick decision making process (decisions are made by an individual or a small number of people, or a single individual)	
Strongly correlated and inter-related with respect to Innovation and entrepreneurship	(Robles-Estrada and Gómez-Suárez, 2007; Gray, 2006; Gunasekaran et al., 1999)
High innovatory potential	
More extensive use of external linkages for Innovate.	(Laforet and Tann, 2006; Hoffman et al., 1998; Barnett and Storey, 2000)
Un bureaucratic processes, flat and flexible structures	(Deros et al., 2006; Levy and Powell, 1998; Massa and Testa, 2008)
Strong inter and intra-firm relationships , managing a great amount of information	(Carbonara, 2005; Chen et al., 2007)
Good at multi-tasking	(Schatz, 2006; Axelson; 2007)
Focused on gaining instant gratification with technology solutions.	(Schatz, 2006)
Informal and dynamic strategies	(Sharma and Bhagwat, 2006)
Capable of going international early and rapidly	(Gassmann and Keupp, 2007)
Possessing tight control over production processes due to close management involvement	(Levy and Powell, 1998)
Productive	(Beck et al., 2005)
Knowledge creating	(Egbu et al., 2005; Levy et al., 2003)
Capable of fast learning and adapting routines and strategy	(Axelson, 2005)
Great potential to adapt new production methods	
Creating astute alliances, networking	(Dijk et al., 1997; Massa and Testa, 2008; Karaev et al., 2007)

Table 3. Some of the major disadvantages of SMEs.

Disadvantage	References
Scarce resources and manpower	(Axelson, 2007; Abdul-Nour et al., 1999; Jansson and Sandberg, 2008)
Limited degree of information technology (IT) implementation	(Wang and Chou, 2008; Eikebrokk and Olsen, 2007; Sarosa and Zowghi, 2003)
Weak at converting research and development into effective innovation	(O'Regan et al., 2006a; O'Regan et al., 2006b)
Lacking some of the essential resources for innovation (poor innovative capabilities) Severe resource limitations in R&D	(Dickson and Hadjimanolis, 1998; Massa and Testa, 2008; Tiwari and Buse, 2007)
Strategy is based on low price, high quality offerings, rather than new product innovations	(Hobday et al., 2004)
Not having formal R&D activities	(Adams et al., 2006; Bougrain and Haudeville, 2002)
Strategy formulation on the basis of what available, lack a long run perspective	(Gomez and Simpson, 2007; Lindman, 2002)
Reliance on small number of customers, and operating in limited markets. Reactive and fire fighting mentality.	(Sharma and Bhagwat, 2006)
Rely on outdated technology, labor intensive and traditional management practices	(Deros et al., 2006; Beck et al., 2005; Caputo et al., 2002)
Lagging in the export, lack the resources necessary to enter foreign markets	(Mahajar et al., 2006'; Jansson and Sandberg, 2008)
Lack of formal competitor analysis, data collection during NPD processes.	(Woodcock et al., 2000)
Absolute size , fewer technological assets	(Narula, 2004)

Differences in R&D between SMEs and large firms

Small and medium-sized businesses are often edged out by their larger counterparts in today's competitive business environment. Until now, large multinational corporations enjoyed the advantage of having affordable resources spread out across the globe. Small and medium-sized enterprises (SMEs) typically suffer from lack of resources; their central role in the development of technology- and science-driven industries is paradoxical (Partanen et al., 2008). Therefore, virtual teams are able to provide a reliable structure to promote SMEs. Most products are multi-technology in nature, and multiple skills are needed; few companies, regardless of their size, can afford to maintain R&D facilities with world-class competencies in many different sectors (Narula, 2004). Innovation is equally important for large and small firms in the contemporary competitive and changing market (Dickson and Hadjimanolis, 1998). The ability of SMEs to meet growing consumer expectations is largely based on their capability to innovate and deliver new products at competitive prices. Innovation is a key driver of sustainable competitive advantage and one of the key challenges for SMEs (O'Regan et al., 2006b). Building global teams and Internet-related capabilities are now options for all companies, regardless of size and location (Bergiel et al., 2008). In every organization, regardless of size, profit, over the last decades, R&D teams have become increasingly virtual (Kratzer et al., 2005; Leenders et al., 2003).

On the other hand, some authors argue that large firms appear to have been more innovative rather than small firms (Tether, 1998). Especially in IT industry large firms create more IT innovation than do small firms (Patrakosol and Olson, 2007). In multinational companies, the use of dispersed constellations in R&D activities is seen to be

increasing (McDonough et al., 2001; Richtne and Rognes, 2008). Jeong (2003), in a survey of 179 US and 250 Chinese firms, explores the role of firm size in facilitating the relationship between multinational expansion and new product performance. The study shows that the firm size effects appear to be significant among Chinese firms, but not in the US sample. The article also shows that US firms can incorporate the benefits of international expansion into their new product development efforts, irrespective of their size. However, although large companies have sufficient resources for investing in innovation, they suffer from a variety of issues that may make them less innovative (Laforet, 2007); larger firms are able to avail themselves of the flexibility long enjoyed by SMEs (Narula, 2004).

SMEs and virtual teams working

Virtuality has been presented as one solution for SMEs aiming to increase their competitiveness (Pihkala et al., 1999). Karaev (2007) in a comprehensive literature has shown the benefits of establishing clusters as an efficient tool for overcoming the size limitations of SMEs. Geographical proximity brings so-called agglomeration effects in terms of higher specialization, innovation and knowledge transfer, which results in costs reduction and improving the competitiveness of industrial sectors, regions and nations. Small businesses must leverage the adoption process to maximize the speed and ease of technology transfer from its partners. Only through cooperation in the adoption of innovations can inter-organizational networks function optimally (Hausman, 2005). Past literature often hypothesized that SMEs did not innovate in formally recognized ways and that they made much more extensive use of external linkages (Laforet and Tann, 2006; Hoffman et al., 1998; Barnett and Storey, 2000). To survive in the global economy SMEs have to improve their products and processes exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). If small firms want to make a step change in their technological and innovation base they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to focus on core competences for efficiency matters; they need to cooperate with external partners to compensate for other competences and resources. This is especially the case in the field of new product development, where SMEs face specific problems compared to large firms (Pullen et al., 2008).

Despite the widespread publicity of information technology, the application of internet technology to upgrade and enhance the product design and business operation by most enterprises, especially for the SMEs, is still at its infancy (Zhan et al., 2003). Lin et al. (2007) found that although almost all senior executives and managers were committed to the IT investments in enterprise during the implementation stage, most of these organizations did not manage user resistance effectively. The SMEs are one of the sectors that have a strong potential to benefit from advances in ICTs and the adaptation of new business modes of operation. The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtually invention (Miles et al., 2000). The use of ICTs can be considered as key factors for innovation and entrepreneurship. ICTs are a must for SMEs to innovate (Redoli et al., 2008). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). SMEs have lack of capital investment for systematic use of information, developing organization processes and technology development. Three out of the eleven organizations used the intranet for knowledge identification. This is basically a data warehouse with data on previous projects and employees (those involved in projects, together with their skills and competences) (Egbu et al., 2005). This indicates that organizations, especially SMEs, do not fully explore the potential benefits of IT for growth. Levy et al. (2003) state that SMEs are knowledge creators but are poor at knowledge retention. They need to be proactive in knowledge sharing arrangements to recognize that knowledge has value and the value added is derived from knowledge exchange (Egbu et al., 2005).

AN OVERVIEW OF SMES IN IRAN AND MALAYSIA

Before going to data collection and analyzing the results, an overview of the situation of SMEs in Iran and Malaysia is provided to increase knowledge about these developing countries. The current trend of economic growth and rapid industrial development has made Malaysia one of the most open economies in the world. Under the Ninth Malaysia Plan (2006-2010), the Government devotes and designs a SME development plan to help SMEs to meet the challenges in the competitive global business environment (Zulkifli-Muhammad et al., 2010).

The role of SMEs in Malaysia and Iran's economic development is well recognized. SMEs represent over 99% of total establishments, but contribute only 32% of gross domestic product (GDP), in comparison to over 40% GDP contribution in other regional economies such as Thailand, Taiwan and Korea and more than 55% in countries like China and Japan (SME Annual Report, 2006). Therefore, major opportunities for SMEs in Malaysia to expand their role are pending. Malaysian SMEs have not moved fast enough to their traditional role of developing new products. Same as Malaysia most SMEs in Iran are still conventional. Their school of thought belongs to the industrial age and their efforts are

not aligned with the requirements of the knowledge age. Today's changes require a new model of thought as a basic requirement (Jafari et al., 2007). Indeed, there are huge opportunities for SMEs to grow and become active and increase their level of contribution as the case of SMEs in developed economies by implementing virtual R&D teams in the NDP.

The purpose of choosing these two developing countries was due to the potential growth of SMEs and the creation of a network of SMEs that might be geographically dispersed, but virtually linked. Thus, the participating members focus on their specialized tasks but also share their knowledge and experience to create resources of an agile and flexible structure.

RESEARCH HYPOTHESES, METHODOLOGY AND DATA COLLECTION

The focus of the investigation is on virtual R&D projects in SMEs. Data for this research are gathered from the desk study and survey in Malaysian and Iranian SMEs. A web based questionnaire was designed and sent to Malaysian SMEs. Its translated Persian version was sent to Iranian manufacturing SMEs. Due to the fact that these countries adopt different definitions of SMEs depending on their business interests, the data were tailored accordingly. Based on these data analysis, some interpretations and formulation of the link between R&D virtual teams and SMEs performance from financial points of view are developed. Advanced statistical methods are used and analyses are carried out to examine the effect of virtuality on SMEs outputs.

This study attempts to identify the effect of virtuality in the growth of SMEs in Iran and Malaysia. Despite knowing that virtual environments can be created using the internet facilities and there could be similarities of such environments irrespective of geographical location, this study, however, also intended to identify if there is any significant difference between these countries. To summarize, the objectives of the survey attempted to examine two relevant hypotheses:

Hypothesis 1

Virtual team activities in SME are positively related to SME's growth.

Hypothesis 2

There is no significant difference between Iranian and Malaysian SMEs growth in which virtual teams are applied.

To that end a questionnaire was developed to collect data for this research. In order to achieve the objectives of the study an online questionnaire has been sent to relevant SMEs in both countries. The rapid expansion of internet users has given web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002). Denscombe's (2006) findings encouraged social researchers to use web-based questionnaires with confidence and the data produced by web-based questionnaires were equivalent to that produced by paper-based questionnaires. Another authors emphasized that the data provided by Internet methods were of at least as good quality as those provided by traditional paper-and-pencil methods (Gosling et al., 2004; Deutskens et al., 2006). However, minor differences occur between the two survey methods; online respondents provide more improved suggestions (Deutskens et al., 2006) and tended to be slightly longer than those from the paper version, and the differences are not statistically significant (Denscombe, 2008).

The main sampling targets were managing director, R&D manager, new product development manager, project and design manager and appropriate persons who were most familiar with the R&D issue in the firm. For better understanding, the questionnaire has been prepared in two different languages, English and Persian. The Iranian respondents were able to select either English version or Persian version of the questionnaire. Out of 947 respondents 210 (22.1%) firms responded to the questionnaire completely and the rest answered it partially. This response rate was satisfactory since accessing the managers is usually difficult. 91 firms met the criteria of SMEs definition for this research. The rest responses were deducted from the analysis.

A descriptive cross-tabulation statistic is done to find the frequency and relationship between the countries and virtual team as illustrated in Table 4. The result shows that Iranian SMEs employed virtual team in R&D activities more than double of Malaysian SMEs (71.4 and 33.3% respectively).

SURVEY RESULTS

Background of respondents

As virtuality is relatively a new idea and competent individuals should get involved, the job position of respondents in the company was the first aspect to be investigated as a background. The respondents to the survey were mainly the Managing Directors or the persons who were in charge of R&D and New Product Development of the companies. The results are presented in Table 5.

The second aspect investigated is the company size and turnover according to Malaysian SME definition which are different from that of Iranian ones. Figures 1 and 2 show that the respondents were mostly from small companies. Small-sized firms defined in this study have less than 50 full-time employees and less than $2.8 million turnover last year.

Hypotheses

The following hypothesis was formulated for conducting the significance test from the responses of SMEs.

Hypothesis 1: 'Employee virtual team in SME is positively related to SME's growth'

H_0: $\mu_1 - \mu_2 = 0$, there is no significant difference between the SMEs turnover that employed virtual team and did not employ virtual team.

H_1: $\mu_1 - \mu_2 \neq 0$, there is a significant difference between SMEs turnover that employed virtual team and did not employ virtual team.

The Fisher's exact test by using SPSS was employed for analyzing the test. The results in Table 6 show that the p-value is lower than 0.05 (significant level); hence the null

Table 4. Cross-tabulation between country and virtual team.

Country		With virtual team		Total
		Yes	No	
Iran	Count	35	14	49
	% within country	71.4	28.6	100.0
	% of total	38.5	15.4	53.8
Malaysia	Count	14	28	42
	% within country	33.3	66.7	100.0
	% of total	15.4	30.8	46.2
Total	Count	49	42	91
	% within country	53.8	46.2	100.0
	% of total	53.8	46.2	100.0

Table 5. Position of respondents in the company.

Position in the company	Frequency	Percentage (%)
Managing director	35	38.5
R&D manager	10	11.0
New product development manager	10	11.0
Project manager	11	12.1
Others (CEO, GM, QC manager, etc.)	25	27.5
Total	91	100

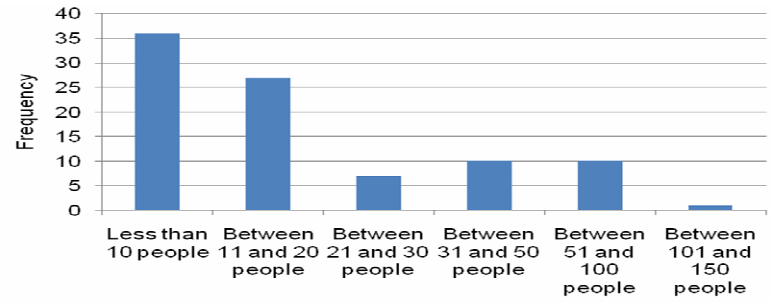

Figure 1. Background of respondents: number of employee (company size).

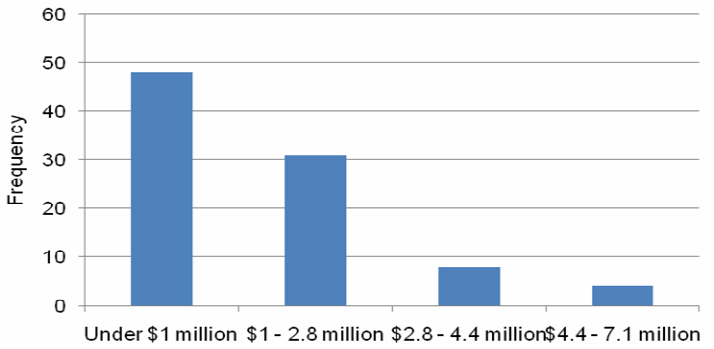

Figure 2. Background of respondents: company turnover.

Table 6. The fisher's exact test results.

Country	Test	Value	Exact significance of *P*-value. (2-sided)
Iran	Fisher's exact test	7.685	.033
	Number of valid cases	49	
Malaysia	Fisher's exact test	8.315	.022
	Number of valid cases	42	

Table 7. Test statistics results grouped by country.

		Turnover	Virtual team	
Mann-Whitney U		954.000	637.000	
Z		-.662	-3.614	
P-value (2-tailed)		.520	.000	
Ranks	**Country**	**N**	**Mean rank**	**Sum of ranks**
Turnover	Iran	49	44.47	2179.00
	Malaysia	42	47.79	2007.00
	Total	91		
With virtual team	Iran	49	38.00	1862.00
	Malaysia	42	55.33	2324.00
	Total	91		

the null hypothesis was rejected. In short, it can be concluded that there was a significant difference between the SMEs turnover that employed virtual team and did not employ virtual teams. Taking advantage of virtual teams enables companies to gain more revenue. Analysis of the survey for Iranian and Malaysian SMEs shows that SMEs which implemented virtual R&D teams have considerably higher growth compared to the traditional SMEs which face increased competition costs due to geographical limits.

Hypothesis 2: 'There is no significant difference between Iranian and Malaysian SMEs growth on employed virtual team'

H_0: $\mu_1 - \mu_2 = 0$, there is no significant differences between Iranian and Malaysian SMEs turnover on employed virtual team.

H_1: $\mu_1 - \mu_2 = 0$, there is a significant difference between Iranian and Malaysian SMEs turnover on employed virtual team.

The nonparametric Mann-Whitney *U* test for two independent samples (Iranian and Malaysian SMEs) was utilized for determining whether or not the values of a particular variable differ between two groups. From the Mann-Whitney *U* test results (Table 7), there was a significant difference between Iranian and Malaysia SMEs (*P*-value = 0. 000) on employed virtual team. Therefore, Mann-Whitney U test and descriptive cross-tabulation statistics (Table 4) results are with Iranian SMEs employed virtual team in R&D activities more than Malaysian SMEs. It means using virtual R&D teams in Iranian SMEs are more popular than Malaysian SMEs. Hypothesis 1 finding in Table 7 shows there was no significant difference between Iranian and Malaysia SMEs turnover (P-value = 0.520 > 0.05) on employed virtual team. It means higher revenue belonged to the SMEs that use virtual R&D teams. The negative Z statistics indicate that the rank sums are lower than their expected values.

Conclusion

This paper has presented the results from a comprehensive review and survey finding on different aspects of virtual teams in SMEs. We found that there was a significant difference between the SMEs turnover employed virtual teams and unemployed virtual teams. Furthermore, it was found that there was a significant difference between Iranian and Malaysia SMEs on employed virtual team. Iranian SMEs employed virtual team in R&D activities more than Malaysian SMEs (71.4 and 33.3 percent respectively). Many SMEs have limited recourses, and it is well-known for their dynamic behavior in contrast to the difficulty of diverting skilled personnel from day-by-day activities, to undertake process re-engineering and R&D. Therefore, applying virtual R&D team in SMEs is a foundation of high-growth SMEs.

The governments of developing countries have to be active in creating opportunities and networks for building SMEs' linkages and networks to succeed in R&D ventures. While larger organizations by their nature can afford the risk of making mistakes, small to medium enterprises (SMEs) are typically more vulnerable and, hence, need a structured low risk approach such as virtual R&D teams. With virtual R&D team the gap between large organizations and SMEs is closing and the pattern of winning in the market space is changing due to technological advances. Competitive advantage, which once belonged exclusively to the large firms, is now becoming available to SMEs through geographically open boundaries created by the virtual team. Reviewing the literature and survey finding shows that SMEs can achieve higher growth rates by the usage of virtual teams.

Most of the research activities relevant for SMEs do not encourage and support R&D collaboration and technology transfer. Benefiting from the cross functional virtual R&D teams beyond the organizations or countries are therefore vital to fill this gap, unlock growth opportunities for SMEs through research, and help them to carry out or outsource research in order to develop new technology based products, processes and services, explore research results, acquire technological know-how and train their employees to incorporate new developments. However, the literature so far has not paid adequate attention to the virtual R&D team activities in SMEs. While some studies have been conducted on model usage in MNCs and large companies, applications within SMEs remain largely un-documented. In the competitive era it is obvious that the survival of the SMEs will be determined first and foremost by their ability to manufacture/supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources. In order to face this challenge SMEs reinforce to create synergies via virtual R&D team that allows firms to overcome difficulties and succeeds. Therefore, managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage such as virtual R&D. Future research needs to design infrastructures to support virtual R&D team in SMEs. New ways of communicating and interacting among team members in virtual environments will necessitate being developed and implemented. Future research should concentrate on above mentioned gab as well as find a common and consistent definition for SMEs in order to make a universal platform to communicate in a smooth manner with the developed world.

ACKNOWLEDGEMENTS

This research was funded by a grant from the University of Malaya (Grant No. PS404/2009C), the authors acknowledge this support. In addition, the authors are grateful to the editors and two anonymous reviewers for their helpful and insightful on the first version of this document.

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Europen Journal of Educational Studies 1(3), 2009

VIRTUAL TEAMS FOR NEW PRODUCT DEVELOPMENT – AN INNOVATIVE EXPERIENCE FOR R&D ENGINEERS

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Abstract : *New interaction tools such as internet allows companies to gain valuable input from research and development (R&D) engineers via virtual teams. Consequently engineers also get more expertise in diminutive timeframes. Virtual R&D teams present the key impetus to the technology acquisition process. The present knowledge-economy era is characterized by short product life-cycles. Virtual R&D teams may reduce time-to-market, make available a large pool of new product know-how and provide greater flexibilities which are the key success factors in a competitive market. This comprehensive review contains almost 100 references and covers the recent literature with emphasis on topic. The review has focused on authentic and reputed publications and extracts the results. This article presents the type of virtual teams and their main features and explains how virtual R&D team can play a prominent role in developing new products. The article is evolved future study guideline and also illustrates how to apply virtual interaction tools and integrate engineers into the innovation process. Management of virtual R&D teams in new product development (NPD) processes in an innovative, effective and efficient is of a high importance, but the issue has been poorly addressed in the previous studies. Findings show that virtual R&D team provides valuable input for new product development and R&D engineers are able to attain virtual experience.*

Keywords: *Virtual R&D Teams, New Product Development, Virtual Experience, R&D Engineers*

INTRODUCTION

Information technology is providing the infrastructure necessary to support the development of new organizational forms. Virtual teams represent one such organizational form, one that could revolutionize the workplace and provide organizations with unprecedented levels of flexibility and responsiveness (Powell, Piccoli, & Ives, 2004). Virtual teams afford many advantages to organizations, including increased knowledge sharing (Pauleen, 2003) and employee job satisfaction and commitment, as well as improved organizational performance (Furst, Reeves, Rosen, & Blackburn, 2004). Virtual teams are believed to be an important element in future R&D organization (Gassmann & Von Zedtwitz, 2003). Many research and development (R&D) organizations and teams currently use a specialized knowledge portal for research collaboration and knowledge management (Lee, Kim, & Koh, 2009).

New product development (NPD) teams are integral components of firms that develop, manufacture, and sell technological offerings. Complex NPD tasks are difficult to solve, involving different functional departments, experience of engineers, judgment and tradeoffs (Enge, 2004). Given the complexities involved in organizing face-to-face interactions between team members and, leveraging the advancements in electronic communication technologies, firms are employing virtual teams in product development activities. Considering the lack of industrial experiences for engineering students, universities look for a suitable situation in which the students can perform a design project not limited to paper calculation. Virtual NPD team can be a solution to compensate the lack of industrial experience of engineer students.

This paper with a comprehensive review of literature and related resources covering the topic presents type of virtual teams, examples of uses of virtual team, and their benefits, draw back and main features and explains how virtual

R&D team can play a prominent role in developing new products. The article also illustrates NPD and its relationship with virtuality and elaborates different NPD process and finally team effective virtual team will also be discussed.

Definition of Virtual Team

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies". Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel, Geister, & Konradt, 2005), different authors have identified diverse. Along with Bal and Teo (2001) it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized (Lee-Kelley & Sankey, 2008) although (Bal & Teo, 2001; Paul, Seetharaman, Samarah, & Peter Mykytyn, 2005; Wong & Burton, 2000) included temporary in virtual team definition but some authors like Gassmann and Von Zedtwitz (2003) use may be temporary for some team members.

Table 1 Common criteria of virtual team

Characteristics of virtual team	**Descriptions**	**References**
Common criteria	1. Geographically dispersed (over different time zones)	(Dafoulas & Macaulay, 2002; Lee-Kelley & Sankey, 2008; Nemiro, 2002; Peters & Manz, 2007; Shin, 2005; Wong & Burton, 2000)
	2. Driven by common purpose(guided by a common purpose)	(Bal & Teo, 2001; Gassmann & Von Zedtwitz, 2003; Hertel et al., 2005; Rezgui, 2007; Shin, 2005)
	3. Enabled by communication technologies	(Bal & Teo, 2001; Lee-Kelley & Sankey, 2008; Nemiro, 2002; Peters & Manz, 2007)
	4. Involved in cross-boundary collaboration	(Bal & Teo, 2001; Gassmann & Von Zedtwitz, 2003; Precup, O'Sullivan, Cormican, & Dooley, 2006; Rezgui, 2007)
Other characteristics	1. It is not a permanent team	(Bal & Teo, 2001; W F Cascio & Shurygailo, 2003; Leenders, Engelen, & Kratzer, 2003; Paul et al., 2005; Wong & Burton, 2000)
	2. Small team size	(Bal & Teo, 2001)
	3. Team member are knowledge workers	(Bal & Teo, 2001; Kirkman, ROSEN, TESLUK, & GIBSON, 2004)
	4. Team members may belong to different companies	(Dafoulas & Macaulay, 2002; Leenders et al., 2003)

A summary of definition of virtual team may be taken as: small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks (Ale Ebrahim, Ahmed, & Taha, 2009b).

Types of Virtual Team

Generally, we can differentiate various forms of "virtual" work depending on the number of people involved and the degree of interaction between them. The first is "*telework*" (telecommuting) which is done partially or completely outside of the main company workplace with the aid of information and telecommunication services."*Virtual groups*" are composed of two or more teleworkers engaged in a lasting relationship, pursuing a common interest and each member reports to the same manager (Ahuja, Galletta, & Carley, 2003). In contrast, a "*virtual team*" exists when the members of a virtual group interact with each other in order to accomplish common goals. Finally, "*virtual communities*" are larger entities of distributed work in which members participate via the Internet, guided by common purposes, roles and norms. In contrast to virtual teams, virtual communities are not implemented within an organizational structure but are usually initiated by some of their members (Li, 2004). Examples of virtual communities are open source software projects (Hertel et al., 2005). Teleworking is viewed as an alternative way to organize work that involves the complete or partial use of ICT to enable workers to get access to their labor activities from different and remote locations (Martinez-Sanchez, Pérez-Pérez, de-Luis-Carnicer, & Vela-Jiménez, 2006). Telework provides cost savings to employees by eliminating time-consuming commutes to central offices and offers employees more flexibility to co-ordinate their work and family responsibilities (Johnson, Heimann, & O'Neill, 2001).

Examples of Uses of Virtual Team

Working in today's business world is like working in a world where the sun never sets. Rezgui (2007) investigates the effectiveness of virtual teams, and any other suitable form of virtual collaboration, in the construction sector, and explores the factors that influence their successful adoption. May and Carter (2001) in their case study of virtual team working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits are better quality, reduced costs and a reduction in the time-to-market (between 20% to 50%) for a new product vehicle. New product development (NPD) requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough, Kahn, & Barczak, 2001; Ozer, 2000) and NPD teams are necessary in almost all businesses(Leenders et al., 2003). In addition, the pressure of globalization competition companies face increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements(Cummings & Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage(Taifi, 2007).

Benefits and Draw Back of Virtual Team

The availability of a flexible and configurable base infrastructure is one of the main benefits of virtual teams (Ale Ebrahim, Ahmed, & Taha, 2009a). Virtual R&D teams which members do not work at the same time or place (Stoker, Looise, Fisscher, & De Jong, 2001) often face tight schedules and a need to start quickly and perform instantly (Munkvold & Zigurs, 2007). As a drawback, virtual teams are particularly vulnerable to mistrust, communication break downs, conflicts, and power struggles (Rosen, Furst, & Blackburn, 2007). On the other hand, virtual teams reduce time-to-market (May & Carter, 2001). Lead time or time to market has been generally admitted to be one of the most important keys for success in manufacturing companies (Sorli, Stokic, Gorostiza, & Campos, 2006). Table 2 summarizes some of the main advantages and
Table 3 some of the main disadvantages associated with virtual team. We are in a transient phase that is pushing out beyond the envelope of team fundamentals into a space where we begin to lose track of reality (Qureshi & Vogel, 2001). Clearly the rise of network technologies has made the use of virtual teams feasible (Beranek & Martz, 2005). Finally organizational and cultural barriers are another serious impediment to the effectiveness of virtual teams. Many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa & Leidner, 1999).

Table 2: some of the main advantages associated with virtual team

Advantages	**Reference**
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli, Powell, & Ives, 2004))	(Bergiel, Bergiel, & Balsmeier, 2008; Biuk-Aghai, 2003; Boudreau, Loch, Robey, & Straub, 1998; Wayne F. Cascio, 2000; Fuller, HARDIN, & DAVISON, 2006; Kankanhalli, Tan, & Wei, 2006; Lipnack & Stamps, 2000; Liu & Liu, 2007; McDonough et al., 2001; Olson-Buchanan, Rechner, Sanchez, & Schmidtke, 2007; Prasad & Akhilesh, 2002; Rice, Davidson1, Dannenhoffer, & Gay, 2007)
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo & Jr., 2005)]	(T.-Y. Chen, 2008; Ge & Hu, 2008; Guniš, Šišlák, & Valčuha, 2007; Kankanhalli et al., 2006; Kusar, Duhovnik, Grum, & Starbek, 2004; Lipnack & Stamps, 2000; May & Carter, 2001; Mulebeke & Zheng, 2006; Prasad & Akhilesh, 2002; Shachaf, 2008; Sorli et al., 2006; Sridhar, Nath, Paul, & Kapur, 2007; Zhang, Shen, & Ghenniwa, 2004)
Able to tap selectively into center of excellence, using the best talent regardless of location	(Badrinarayanan & Arnett, 2008; Boudreau et al., 1998; Boutellier, Gassmann, Macho, & Roux, 1998; Wayne F. Cascio, 2000; Criscuolo, 2005; Fuller et al., 2006; Furst et al., 2004; Prasad & Akhilesh, 2002; Samarah, Paul, & Tadisina, 2007)
Greater degree of freedom to individuals involved with the development project	(Badrinarayanan & Arnett, 2008; Ojasalo, 2008; Prasad & Akhilesh, 2002)
Greater productivity, shorter development times	(McDonough et al., 2001; Mulebeke & Zheng, 2006)
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	(T. Y. Chen, Chen, & Ch, 2008; Martins, Gilson, & Maynard, 2004; Rice et al., 2007)
Optimize the contributions of individual members toward the completion of business tasks and organizational goal	(Samarah et al., 2007)
Better team outcomes (quality, productivity, and satisfaction)	(Gaudes, Hamilton-Bogart, Marsh, & Robinson, 2007; Ortiz de Guinea, Webster, & Staples, 2005; Piccoli et al., 2004)
Higher team effectiveness and efficiency	(May & Carter, 2001; Shachaf & Hara, 2005)

Table 3: some of the main disadvantages associated with virtual team

Disadvantages	**References**
Decrease monitoring and control of activities	(Pawar & Sharifi, 1997)
Vulnerable to mistrust, communication break downs, conflicts, and power struggles	(Baskerville & Nandhakumar, 2007; Wayne F. Cascio, 2000; Kirkman, Rosen, Gibson, Tesluk, & McPherson, 2002; Rosen et al., 2007; Taifi, 2007)
Challenges of determining the appropriate task technology fit	(Badrinarayanan & Arnett, 2008; Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003; Ocker & Fjermestad, 2008; Pawar & Sharifi, 2000; Qureshi & Vogel, 2001)
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	(Badrinarayanan & Arnett, 2008; Bell & Kozlowski, 2002; Boutellier et al., 1998; Griffith et al., 2003; Jacobsa et al., 2005; Kankanhalli et al., 2006; Munkvold & Zigurs, 2007; Paul, Seetharaman, Samarah, & Peter Mykytyn, 2005 ; Poehler & Schumacher, 2007; Shachaf, 2005)
Sometimes requires complex technological applications	(Badrinarayanan & Arnett, 2008; Bergiel et al., 2008)

New Product Development

Product development definition used by different researchers with slightly different ways but generally it is the process that covers product design, production system design and product introduction processes and start of production (Johansen, 2005). New product development (NPD) is widely recognized as a key to corporate prosperity (Lam, Chin, Yang, & Liang, 2007). The product life cycle of goods grows shorter every year. Today, leading-edge firms can exploit global asset configurations to customize existing products and services, and they also have the ability to combine their resources with an expanding knowledge base to create a continuous stream of new products and services (Miles, Snow, & Miles, 2000). With the needs to respond quickly to dynamic customer needs, increased complexity of product design and rapidly changing technologies, the selection of the right set of NPD is critical to a company's long-term success (H. H. Chen, Kang, Xing, Lee, & Tong, 2008) . Also combination of factors such as ever changing market needs and expectations, rough competition and emerging technologies among others, challenges industrial companies to continuously increase the rate of new products to the market to fulfill all these requirements (Sorli et al., 2006).The ultimate objective of all NPD teams is superior marketplace success of the new product (Akgun, Lynn, & Yilmaz, 2006). In light of the above product innovations are central in securing a firm's competitive advantage in international markets (Jeong, 2003). NPD is vital and needs to be developed both innovatively and steadily (H. H. Chen et al., 2008).

NPD and virtuality

New product development (NPD) has long been recognized as one of the corporate core functions (Huang, Soutar, & Brown, 2004). During the past 25 years NPD has increasingly been recognize as a critical factor in ensuring the continued existence of firms (Biemans, 2003).The rate of market and technological changes has accelerated in the past years and this turbulent environment requires new methods and techniques to bring successful new products to the marketplace (González & Palacios, 2002). Particularly for companies with short product life cycles, it is important to quickly and safely develop new products and new product platforms that fulfill reasonable demands on quality, performance, and cost (Ottosson, 2004). The world market requires short product development times (Starbek & Grum, 2002) therefore in order to successfully and efficiently get all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams(Precup et al., 2006). Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Badrinarayanan & Arnett, 2008; Jacobsa et al., 2005; Schmidt, Montoya-Weiss, & Massey, 2001). New product development requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough et al., 2001; Ozer, 2000) and NPD teams are necessary in almost all businesses(Leenders et al., 2003). In addition, the pressure of globalization competition companies face increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements(Cummings & Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage(Taifi, 2007).

New product development process

Today's uncertain and dynamic environment presents a fundamental challenge to the new product development process of the future (MacCormack, Verganti, & Iansiti, 2001). New product development is a multi-dimensional process and involves multiple activities (Ozer, 2000). Several authors proposed different conceptual models for the NPD process, beginning from the idea screen and ending with the commercial launch. Kusar al. (2004) summarized different stage of new product development which in earlier stages , the objective is to make a preliminary market, business, and technical assessment whereas at the later stages the propose is to actually Design and develop.

1- Definition of goals (goals of the product development process)
2- Feasibility study (term plan, financial plan, pre-calculation, goals of market)
3- Development (first draft and structure of the product, first draft of components, product planning and its control processes)
4- Design (design of components, drawing of parts, bills of material)

The model of Cooper Figure 1, called the Stage-Gate System is one of the most widely acknowledged system in NPD (Rejeb, Morel-Guimaraes, & Boly, 2008). The Stage-Gate System model divides the NPD into discrete stages, typically five stages. Each stage gathers a set of activities to be done by a multifunctional project team. To enter into each stage, some conditions and criteria have to be fulfilled. They are specified in the Gates. A Gate is a project review in which all the information is confronted by the whole team. Some criticism of the method has surfaced, claiming that the steering group assessment in the gate step halts the project for an unnecessarily long time, making the process abrupt and discontinuous (Ottosson, 2004). A closer integration of management through virtual team in the process might be a solution for avoiding such situations.

Stage-Gate process is a method of managing the new product development process to increase the probability of launching new products quickly and successfully. The process provides a blueprint to move projects through the different stages of development: idea generation, preliminary investigation, business case preparation, product development, product testing, and product introduction. This process is used by such companies as IBM, Procter & Gamble, 3M, General Motors, and others. The process is primarily used in the development of specific commercial products, and is more likely to be used in platform projects than in derivative projects.

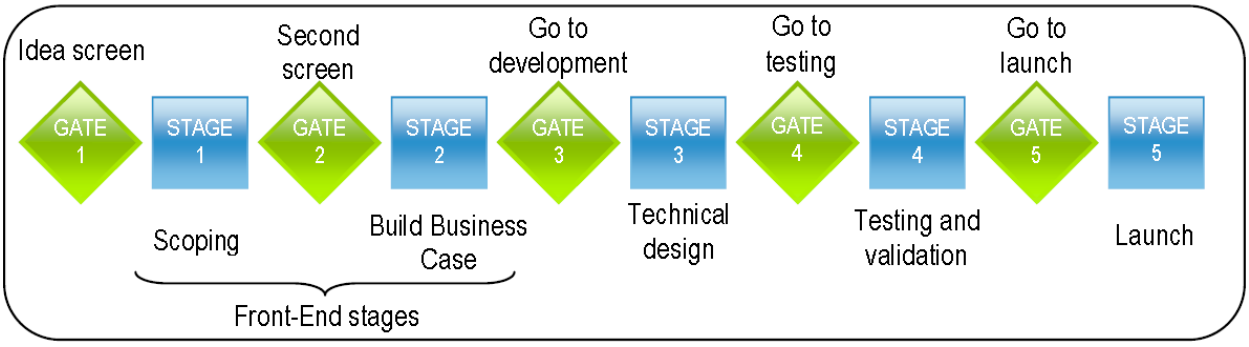

Figure 1 The Stage-Gate system model (source Cooper (2006))

Development Stage-Gate System in NPD process:
The new products plan will support the strategic objectives of the firm and make the best use of its strategic competencies. As it is illustrated in Figure 2, the development stages of the NPD process include the generation of new product ideas, the development of an initial product concept, an assessment of its business attractiveness, the actual development of the product, testing it within the market, and the actual launch of the product in the marketplace. Alongside each of these stages, an evaluation takes place, essentially to determine whether the new product should advance further or be terminated (Tzokas, Hultink, & Hart, 2004).

Effective Virtual Team

A review of the literature shows the factors that impact on the effectiveness of virtual teams are still ambiguous. Many of the acknowledged challenges of effective virtual team working, focus on ensuring good communication among all members of the distributed team (Anderson, McEwan, Bal, & Carletta, 2007). For example, Jarvenpaa and Leidner (1999) found that regular and timely communication feedback was key to building trust and commitment in distributed teams. Lin et al.(2008) study indicates that social dimensional factors need to be considered early on in the virtual team creation process and are critical to the effectiveness of the team. Communication is a tool that directly influences the social dimensions of the team and in addition the performance of the team has a positive impact on satisfaction with the virtual team.

For teams moving from co-location to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams(Kirkman et al., 2002). Despite weak ties between virtual team members, ensuring lateral communication maybe adequate for effective virtual team performance. In terms of implementation, lateral communication in both virtual context and composition teams can be increased by reducing the hierarchical structure of the team (i.e. a flatter reporting

structure and/or decentralization) and the use of enabling computer-mediated communication tools(Wong & Burton, 2000).

Malhotra and Majchrzak's (2004)study of 54 effective virtual teams found that creating a state of shared understanding about goals and objectives, task requirements and interdependencies, roles and responsibilities, and member expertise had a positive effect on output quality. As criteria, effectiveness ratings were Hertel et al.(2005) collected from the team managers both at the individual and at the team level. The results of the field study showed good reliability of the task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara (2005)suggests four dimensions of effective virtual team leadership:

1. Communication (the leader provides continuous feedback, engages in regular and prompt communication, and clarifies tasks);
2. Understanding (the leader is sensitive to schedules of members, appreciates their opinions and suggestions, cares about member's problems, gets to know them, and expresses a personal interest in them);
3. Role clarity (the leader clearly defines responsibilities of all members, exercises authority, and mentors virtual team members); and
4. Leadership attitude (the leader is assertive yet not too "bossy," caring, relates to members at their own levels, and maintains a consistent attitude over the life of the project).

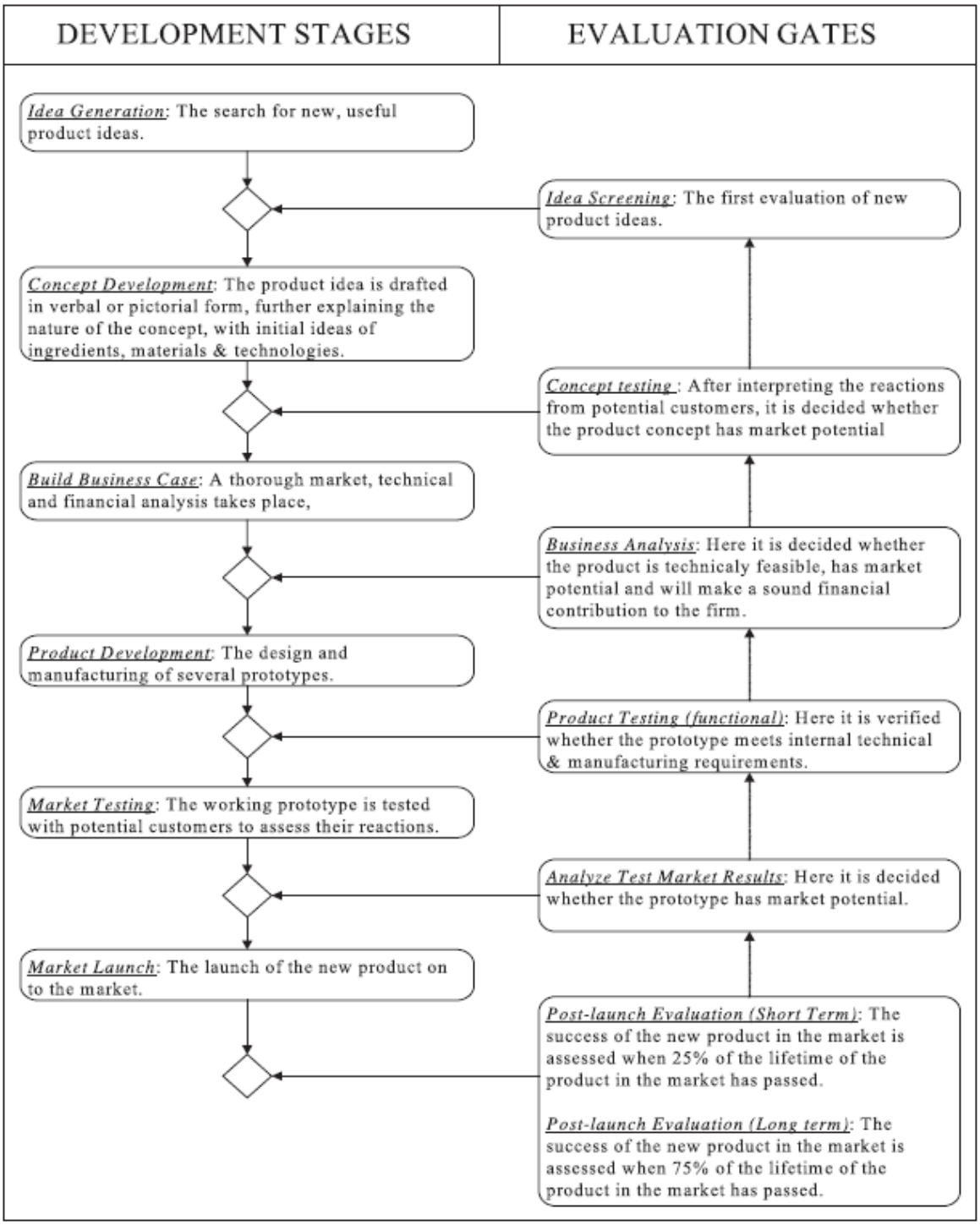

Figure 2 Development stages and evaluation gates in the NPD process (Source: (Tzokas et al. (2004)).

CONCLUSION

Competitive business environments and social pressures are driving the adoption of virtual team working. This paper with a comprehensive review of literature and related resources covering the topic, find that success in implementing virtual team working is more about processes and people than about technology. Organizations are

often naive about the advantages, problems and disadvantages of virtual team working. Virtual teams offer many benefits to organizations striving to handle a more demanding work environment, but also present many challenges and potential pitfalls. With comparing Table 2, with
Table 3 it is clearly obvious that advantages of utilize virtual teams are far from its disadvantages so dealing with it can bring new findings. Virtual teams are a new and exciting work form with many fascinating opportunities. Due to these opportunities, virtual teamwork becomes increasingly popular in organizations and institutions. A suitable situation in which the students can perform a design project not only limited to paper calculation but also earn industrial experiences is working as a virtual NPD team member.

Future research would now seem to be essential for developing a comprehensive study, combining literature survey with case study in different size of companies (e.g. multinational companies and small and medium enterprises) and various type of activities (e.g. research and development and new product development). Such a study would provide an assessing what patterns, practices, or types of activities must virtual NPD teams carry out to achieve effectiveness in the competitive environment?, How such teams should be managed? What types of process structure and technology support should be provided for facilitating such teams?, What different methods of virtual team are uses today and how effective are they?, What benefits and problems arise as a consequence of the creation of virtual team? What is role of different collaborative technologies in supporting the virtual team? and How to make the transition from a more traditional team structure to the more distributed team structure?. These questions and many other practical questions wait for future empirical investigation.

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European Journal of Scientific Research
ISSN 1450-216X Vol.34 No.3 (2009), pp.297-307

http://www.eurojournals.com/ejsr.htm

Innovation and R&D Activities in Virtual Team

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Abstract

Innovation plays a central role in economic development, at regional and national level. In the competitive environment companies are obliged to produce more rapidly, more effectively and more efficiently in new product development which is a result of research and development (R&D) activities. It is necessary for them to put together different capabilities and services with the goal, through cooperation between suppliers and customers, service providers and scientific institutions to achieve innovations of high quality. Depending on the type of industry, the type of business, the type of innovation and the strategic objectives that have been set, firms will regularly have to modify the way in which their R&D and innovation is organized. Nowadays shift from serial to simultaneous and parallel working in innovation has become more commonplace. Literatures have shown that collaboration is as a meta-capability for innovation. By a comprehensive reviewing of literature this article after define a virtual teams and its characteristics, addressing virtual environments innovation and the relationship to R&D activities. Finally conclude that innovation cannot be successful unless the knowledge and information in the R&D project are effectively captured, shared and internalized by the R&D project's virtual team members.

Keywords: Virtual team, Literature review, Innovation, Research and Development

1. Introduction

A growing number of flexible and adaptable organizations have explored the virtual environment as one means of achieving increased responsiveness (Furst et al., 2001). Howells et al. (2003) state the shift from serial to simultaneous and parallel working in innovation has become more commonplace.

Companies put innovation at the heart of their competitive strategy. When innovation is autonomous, the decentralized virtual team can manage the development and commercialization tasks quite well (Chesbrough and Teece, 2002). Blomqvist et al. (2004) emphasized collaboration is as a meta-capability for innovation.

Information technologies offer solutions to typical innovation problems, such as creativity management, new product development, product life cycle management, enabling organizations to tackle the daily challenges of innovation (McKie, 2004). Based on conventional information technologies and Internet-based platforms virtual environments may be used to sustain innovation through virtual interaction and communication. Ozer, M. (2004) study suggested that the Internet's role will be more pronounced for innovative products compared to less innovative products; will be more highlighted for relational new products compared to transactional new products; and will be higher for new industrial products compared to new consumer products. With regard to the organization related factors, the role of the Internet in new product success will be more pronounced when companies' learning, Internet-related technical and marketing capabilities, and collaborative capabilities are high compared to when they are low.

This paper provides a comprehensive review on different aspects of virtual teams and innovation based on authentic and reputed publications, after define innovation and virtual teams and its characteristics, addressing virtual environments innovation and the relationship to R&D activities. Finally conclude that innovation cannot be successful unless the knowledge and information in the R&D project are effectively captured, shared and internalized by the R&D project's virtual team members. Doing an extensive literature survey, further studies are recommended. Managerial implications on those issues are also discussed.

2. Innovation

Innovation has long been recognized as crucial to organizational success and as an important field of research inquiry (Huang et al., 2004). Innovation plays a central role in economic development, at regional and national level (Haga, 2005). Innovation is something new that was introduced in an environment, i.e., a new product, a new way of realizing a process, etc. (Sorli et al., 2006). Therefore, an innovation represents the final stage of a development process, representing the final result achieved and implemented successfully. Innovation correlated with the performance of firms and the new products and process improvements partially account for the higher sales and employment growth as well as the higher profit margins (Dickson and Hadjimanolis, 1998). Product innovation is undoubtedly important (Adams et al., 2006). Depending on the type of industry, the type of business, the type of innovation and the strategic objectives that have been set, firms will regularly (have to) modify the way in which their R&D and innovation is organized (Erkena and Gilsing, 2005). (Dickson and Hadjimanolis, 1998) in their study conclude that the more innovative firms, not only in terms of new products introduced in the last 2 years and their relative novelty, but also in terms of process innovation adopted or locally developed, tend to follow proactive innovation strategies, being first-to-market with new products and investing in order to solve problems, increase capacity or upgrade quality of products. Sometimes the production of new products also involves a new production line. The proactive firms usually have a wider variety of technology sources than less innovative firms.

3. R&D and Innovation

Within the R&D literature, a number of recent studies have explored the connection among complexity of labor, organizational innovation and productivity in R&D (Mote, 2005). In a study von Zedtwitz and Gassmann (2002) analysis of 1021 R&D units and found that research is concentrated in five regions worldwide, while development is more dispersed globally than research. Firms are becoming more interdependent upon each other for successful outcomes in their technological routing. By being a member of an innovation network in one sense can be said to lower the risks of technological failure,

as the burden for exploiting the new technology is no longer borne by one firm (Howells et al., 2003). Precup et al. (2006) conclude that project innovation cannot be successful unless the knowledge and information in the project are effectively captured, shared and internalized by the project's virtual team members. Nordic countries (Finland, Sweden, Denmark and Norway) are very active in innovation cooperation (Arranz and Arroyabe, 2008) on the other hand, firms in countries such as China, Taiwan and South Korea are paying more attention to designing and introducing new products to global markets (Perks and Wong, 2003). Partners take part in R&D networks seeking to gain access to technological resources and to improve their competitive position (Arranz and Arroyabe, 2008). For instance Spanish firms seek to overcome market and technological risks through collaboration with suppliers and customers (Arranz and Arroyabe, 2008).

4. Virtual Team Definition

This era is growing popularity for virtual team structures in organizations (Walvoord et al., 2008, Cascio, 2000). Martins et al. (2004) in a major review of the literature on virtual teams, conclude that 'with rare exceptions all organizational teams are virtual to some extent.' We have moved away from working with people who are in our visual proximity to working with people around the globe (Johnson et al., 2001). Although virtual teamwork is a current topic in the literature on global organizations, it has been problematic to define what 'virtual' means across multiple institutional contexts (Chudoba et al., 2005). It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Virtual teams are comprised of members who are located in more than one physical location. This team trait has fostered extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007). From the perspective of Leenders et al.(Leenders et al., 2003) virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Amongst the different definitions of the concept of a virtual team the following from is one of the most widely accepted: (Powell et al., 2004), ''virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks''. The degree of geographic dispersion within a virtual team can vary widely from having one member located in a different location than the rest of the team to having each member located in a different country (Staples and Zhao, 2006).

4.1. Virtual Team Characteristics

Along with Bal and Teo (2001) finding, it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized (Lee-Kelley and Sankey, 2008) although (Bal and Teo, 2001, Paul et al., 2005, Wong and Burton, 2000) included temporary in virtual team definition but some authors like Gassmann and Von Zedtwitz (2003) use may be temporary for some team members.

5. Benefits and Drawbacks of Virtual Teams

The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. (Anderson et al., 2007). Virtual R&D teams which members do not work at the same time or place (Stoker et al., 2001) often face tight schedules and a need to start quickly and perform

instantly (Munkvold and Zigurs, 2007). On the other hand, virtual teams reduce time-to-market (May and Carter, 2001). Lead Time or Time to market has been generally admitted to be one of the most important keys for success in manufacturing companies (Sorli et al., 2006). Table 2 summarizes some of the main advantages and Table 3 some of the main disadvantages associated with virtual teaming.

Table 1: common criteria of virtual team

Characteristics of virtual team	Descriptions	References
Common criteria	1. Geographically dispersed (over different time zones)	(Dafoulas and Macaulay, 2002, Shin, 2005, Wong and Burton, 2000, Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008)
	2. Driven by common purpose (guided by a common purpose)	(Bal and Teo, 2001, Shin, 2005, Hertel et al., 2005, Gassmann and Von Zedtwitz, 2003, Rezgui, 2007)
	3. Enabled by communication technologies	(Bal and Teo, 2001, Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008)
	4. Involved in cross-boundary collaboration	(Bal and Teo, 2001, Gassmann and Von Zedtwitz, 2003, Rezgui, 2007, Precup et al., 2006)
Other characteristics	1. It is not a permanent team	(Bal and Teo, 2001, Paul et al., 2005, Wong and Burton, 2000)
	2. Small team size	(Bal and Teo, 2001)
	3. Team member are knowledge workers	(Bal and Teo, 2001, Kirkman et al., 2004)
	4. Team members may belong to different companies	(Dafoulas and Macaulay, 2002)

Table 2: some of the main advantages associated with virtual teaming.

Advantages	References
Reducing relocation time and costs, reduced travel costs	(McDonough et al., 2001, Rice et al., 2007, Bergiel et al., 2008, Cascio, 2000, Fuller et al., 2006, Kankanhalli et al., 2006)
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005)]	(May and Carter, 2001, Sorli et al., 2006, Kankanhalli et al., 2006, Chen, 2008, Shachaf, 2008, Kusar et al., 2004, Ge and Hu, 2008, Mulebeke and Zheng, 2006)
More effective R&D continuation decisions	(Cummings and Teng, 2003)
Able to tap selectively into center of excellence, using the best talent regardless of location	(Criscuolo, 2005, Cascio, 2000, Samarah et al., 2007, Fuller et al., 2006)
Greater productivity, shorter development times	(McDonough et al., 2001, Mulebeke and Zheng, 2006)
Greater degree of freedom to individuals involved with the development project	(Ojasalo, 2008)
Higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another)	(Kratzer et al., 2005, Cascio, 2000, Gaudes et al., 2007)
Producing better outcomes and attract better employees	(Martins et al., 2004, Rice et al., 2007)
Provide organizations with unprecedented level of flexibility and responsiveness	(Powell et al., 2004, Hunsaker and Hunsaker, 2008, Chen, 2008, Katzy et al., 2000)
Can manage the development and commercialization tasks quite well	(Chesbrough and Teece, 2002)
Organizations seeking to leverage scarce resources across geographic and other boundaries	(Munkvold and Zigurs, 2007)
Respond quickly to changing business environments	(Bergiel et al., 2008, Mulebeke and Zheng, 2006)
Sharing knowledge, experiences	(Rosen et al., 2007, Zakaria et al., 2004)
Enable organizations to respond faster to increased competition	(Hunsaker and Hunsaker, 2008, Pauleen, 2003)
Better team outcomes (quality, productivity, and satisfaction)	(Gaudes et al., 2007, Ortiz de Guinea et al., 2005)
Most effective in making decisions	(Hossain and Wigand, 2004)
Higher team effectiveness and efficiency	(May and Carter, 2001, Shachaf and Hara, 2005)
Self-assessed performance and high performance.	(Chudoba et al., 2005, Poehler and Schumacher, 2007)
Cultivating and managing creativity	(Leenders et al., 2003)
Improve the detail and precision of design activities	(Vaccaro et al., 2008)
Provide a vehicle for global collaboration and coordination of R&D-related activities	(Paul et al., 2005)

Table 3: some of the main disadvantages associated with virtual teaming.

Disadvantages	References
lack of physical interaction	(Cascio, 2000, Hossain and Wigand, 2004, Kankanhalli et al., 2006, Rice et al., 2007)
everything to be reinforced in a much more structured, formal process	(Lurey and Raisinghani, 2001).
Challenges of project management are more related to the distance between team members than to their cultural or language differences	(Martinez-Sanchez et al., 2006).
Challenges of determining the appropriate task technology fit	(Qureshi and Vogel, 2001, Ocker and Fjermestad, 2008)
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	(Paul et al., 2005 , Poehler and Schumacher, 2007, Kankanhalli et al., 2006)
Will create challenges and obstacles like technophobia (employees who are uncomfortable with computer and other telecommunications technologies)	(Johnson et al., 2001)
Variety of practices (cultural and work process diversity) and employee mobility negatively impacted performance in virtual teams.	(Chudoba et al., 2005)
Team members need special training and encouragement	(Ryssen and Godar, 2000)

6. Virtual and Traditional R&D Teams

Unlike a traditional team, a virtual team works across space, time and organizational boundaries with links strengthened by webs of communication technologies. However, many of the best practices for traditional teams are similar to those for virtual teams (Bergiel et al., 2008). Virtual teams are significantly different from traditional teams. In the proverbial traditional team, the members work next to one another, while in virtual teams they work in different locations. In traditional teams the coordination of tasks is straightforward and performed by the members of the team together; in virtual teams, in contrast, tasks must be much more highly structured. Also, virtual teams rely on electronic communication, as opposed to face-to-face communication in traditional teams. Table 4 summarizes these distinctions (Kratzer et al., 2005). Diversity in national background and culture is common in transnational and virtual teams (Staples and Zhao, 2006).

Table 4: Virtual and traditional R&D teams are usually viewed as opposites.

Fully Traditional Team	Fully Virtual Team
Team members all co-located. Team members communicate face-to-face (i.e., synchronous and personal) Team members coordinate team task together, in mutual adjustment.	Team members all in different locations. Team members communicate through asynchronous and impersonal means. The team task is so highly structured that coordination by team members is rarely necessary.

In particular, reliance on computer-mediated communication makes virtual teams unique from traditional ones (Munkvold and Zigurs, 2007). Kratzer et al.(2005) research shows that traditional R&D teams have become rare. The processes used by successful virtual teams will be different from those used in face-to-face collaborations (FFCs) (Rice et al., 2007). In an innovation network resembling a “traditional” organization, the innovation process is more restricted by location and time. In other words, the innovation process mostly takes place within the framework of physical offices and working hours. In virtual organizations, individuals’ work is not restricted by time and place, and communication is strongly facilitated by IT. Such a product development environment allows a greater degree of freedom to individuals involved with the development project (Ojasalo, 2008). Hence multinational companies (MNC) are more likely to become tightly integrated into global R&D network than smaller unit (Boehe, 2007). Distributed teams can carry out critical tasks with appropriate decision support technologies (Chen et al., 2007).

7. Physical vs. Virtual

Pawar and Sharifi (Pawar and Sharifi, 1997) study of virtual versus collocated team success and classified physical teams versus virtual teams in six categories.

Table **5** summarizes these differences.

Lurey and Raisinghani (2001) base on virtual teams survey in 12 separate virtual teams from eight different sponsor companies in the high technology found that, organizations choosing to implement virtual teams should focus much of their efforts in the same direction they would if they were implementing traditional, co-located teams.

Table 5: Classifying physical teams versus virtual teams

Activity	Physical teams nature	Virtual teams nature
Nature of interaction	opportunity to share work and non-work related information	the extent of informal exchange of information is minimal
Utilization of resources	Increases the opportunity for allocation and sharing of resources	each collaborating body will have to have access to similar technical and non-technical infrastructure
Control and accountability (over and within the project):	Project manager provides the context for ongoing monitoring of activities and events and thus enhances their ability to respond to requirements.	The collaborating bodies were accountable to the task leaders and the project coordinator who had limited authority to enforce any penalties for failure to achieve their tasks
Working environment	they encountered constraints accessing information and interacting with others outside the collocated team within the company	Sometimes not able to share ideas or dilemmas with other partners.
Cultural and educational background	members of the team are likely to have similar and complementary cultural and educational background	the team members varied in their education, culture, language, time orientation and expertise
Technological compatibility:	situated and operating within a single organization, faces minimal incompatibility of the technological systems	compatibility between different systems in collaborating organizations ought to be negotiated at the outset

8. Conclusion

Products are being witnessed every day gaining the knowhow and the right knowledge for keeping pace with the rate and intensity of change has become an inevitable necessity. Virtual teams provide an environment for flourishing innovation in R&D and bring about knowledge spillovers within enterprises bridging time and place, therefore the decision on setting up virtual teams in R&D is not a choice but a requirement. The globalization of and the new waves of global trends in economy, services and business along with advances in telecommunications technology have paved the way for the formation and the performance of virtual teams. While reviewing the previous study refer to Table 2 and Table 3, it's believed that the advantages of working on the basis of virtual teams far outweigh the disadvantages and innovation cannot be successful unless the knowledge and information in the R&D project are effectively captured, shared and internalized by the R&D project's virtual team members.

This paper has provided an extensive review of literature and related resources covering the theme of virtual R&D teams and innovation. Clearly there is a considerable scope for extending this study to specify filed such as small and medium enterprises (SMEs) and relationship with virtual R&D team. Further research has to be done on this topic to fully understand the influence of virtual R&D team on innovation practically. The review shows that whereas a considerable number of studies and research efforts have been conducted and concentrated on innovation or virtual R&D teams, limited work have been directed towards exploring and analyzing the existing inter-relation. Therefore future research shall be aimed at shifting away from investigating innovation and virtual R&D teams separately to the formation and development of a collaborative system which can support a dispersed team effectively. Keeping virtual R&D teams in innovation processes, operating innovatively, effectively and efficiently is of a high importance, but the issue has poorly been addressed simultaneously in the previous studies.

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African Journal of Marketing Management Vol. 1(9) pp. 211-219, December, 2009
Available online http://www.academicjournals.org/ajmm

Review

Modified stage-gate: A conceptual model of virtual product development process

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Accepted 9 November, 2009

In today's dynamic marketplace, manufacturing companies are under strong pressure to introduce new products for long-term survival with their competitors. Nevertheless, every company cannot cope up progressively or immediately with the market requirements due to knowledge dynamics being experienced in the competitive milieu. Increased competition and reduced product life cycles put force upon companies to develop new products faster. In response to these pressing needs, there should be some new approach compatible in flexible circumstances. This paper presents a solution based on the popular Stage-Gate system, which is closely linked with virtual team approach. Virtual teams can provide a platform to advance the knowledge-base in a company and thus to reduce time-to-market. This article introduces conceptual product development architecture under a virtual team umbrella. The paper describes all the major aspects of new product development (NPD), NPD process and its relationship with virtual teams, Stage-Gate system finally presents a modified Stage-Gate system to cope up with the changing needs. It also provides the guidelines for the successful implementation of virtual teams in new product development.

Key words: Modified stage-gate system, virtual product development, conceptual model.

INTRODUCTION

New product development (NPD) is widely recognized as a key to corporate prosperity (Lam et al., 2007). Different products may require different processes, a new product idea needs to be conceived, selected, developed, tested and launched to the market (Martinez-Sanchez et al., 2006). The specialized skills and talents required for the development of new products often reside (and develop) locally in pockets of excellence around the company or even around the world. Firms, therefore, have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). As a result, firms are finding that internal development of all technology needed for new products and processes are difficult or impossible. They must increasingly acquire technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make serious headway due to developments in technology – virtuality in NPD is now technically possible (Leenders et al., 2003). Automotive OEMs (Original equipment manufacturers) have formed partnerships with suppliers to take advantage of their technological expertise in development, design, and manufacturing (Wagner and Hoegl, 2006). As product development becomes the more complex, supply chain also have to collaborate more closely than in the past. These kinds of collaborations almost always involve individuals from different locations, so virtual team working supported by IT, offers considerable potential benefits (Anderson et al., 2007). May and Carter (2001) in their case study of virtual teams working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits in terms of better quality, reduced costs and a reduction in the time-to-market (between 20 - 50%) for a new product vehicle.

Although the uses of the internet in NPD have received considerable attention in the literature, very little is written about the collaborative tool and virtual team implementtation in NPD. On the other hand, Stage-Gate system which defines different steps of product development has

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some criticism and according to the extent of information and communication technology (ICT) need to modify. In forthcoming section the major aspects of new product development (NPD), NPD process and its relationship with virtual teams, Stage-Gate system and finally presents a modified Stage-Gate system will be described.

NEW PRODUCT DEVELOPMENT (NPD) CALLS FOR VIRTUALITY

Product development definition used by different researchers in slightly different ways, but generally it is the process that covers product design, production system design and product introduction processes and start of production (Johansen, 2005). A multidisciplinary approach is needed to be successful in launching new products and managing daily operations (Flores, 2006). In the NPD context, teams developing new products in the turbulent environments encounter quick depreciation of technology and market knowledge due to rapidly changing customer needs, wants, and desires (Akgun et al., 2007). Adoption of collaborative engineering tools and technology (e.g., Web-based development systems for virtual team coordination) was significantly correlated with NPD profitability (Ettlie and Elsenbach, 2007). ICT enhances the NPD process by shortening distances and saving on costs and time (Vilaseca-Requena et al., 2007).

Kafouros et al. (2008) found that internationalization enhances a firm's capacity to improve performance through innovation. Since efficiency, effectiveness and innovation management has different and contradictory natures, it is very difficult to achieve an efficient and innovative network cooperative NPD (Chen et al., 2008b). Supplier involvement in NPD can also help the buying firm to gain new competencies, share risks, move faster into new markets, and conserve resources (Wagner and Hoegl, 2006).

New product development (NPD) has long been recognised as one of the corporate core functions (Huang et al., 2004). During the past 25 years NPD has increasingly been recognized as a critical factor in ensuring the continued existence of firms (Biemans, 2003). The rate of market growth and technological changes has accelerated in the past years and this turbulent environment requires new methods and techniques to bring successful new products to the marketplace (González and Palacios, 2002). Particularly for companies with short product life cycles, it is important to quickly and safely develop new products and new product platforms that fulfil reasonable demands on quality, performance, and cost (Ottosson, 2004). The world market requires short product development times (Starbek and Grum, 2002), and therefore, in order to successfully and efficiently get all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams (Precup et al., 2006).

Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Jacobsa et al., 2005; Badrinarayanan and Arnett, 2008; Schmidt et al., 2001). IT improves NPD flexibility (Durmusoglu and Calantone, 2006). New product development requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough et al., 2001; Ozer, 2000) and NPD teams are necessary in all businesses (Leenders et al., 2003). In addition, the pressure of globalize competition forces companies to face increased pressures to build critical mass, reach new markets, and plug skill gaps. Therefore, NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements (Cummings and Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage (Taifi, 2007).

New product development process

New business formation activities vary in complexity and formality from day-to-day entrepreneurial or customer prospecting activities to highly structured approaches to new product development (Davis and Sun, 2006). Today's uncertain and dynamic environment presents a fundamental challenge to the new product development process of the future (MacCormack et al., 2001). New product development is a multi-dimensional process and involves multiple activities (Ozer, 2000). Kusar et al. (2004) summarized different stage of new product development which in earlier stages, the objective is to make a preliminary market, business, and technical assessment, whereas at the later stages they propose to actually design and develop the product(s).

- Definition of goals (goals of the product development process)
- Feasibility study (term plan, financial plan, pre-calculation, goals of market)
- Development (first draft and structure of the product, first draft of components, product planning and its control processes)
- Design (design of components, drawing of parts, bills of material)

Stage-gate system in NPD: Several authors proposed different conceptual models for the NPD process, beginning from the idea screening and ending with the

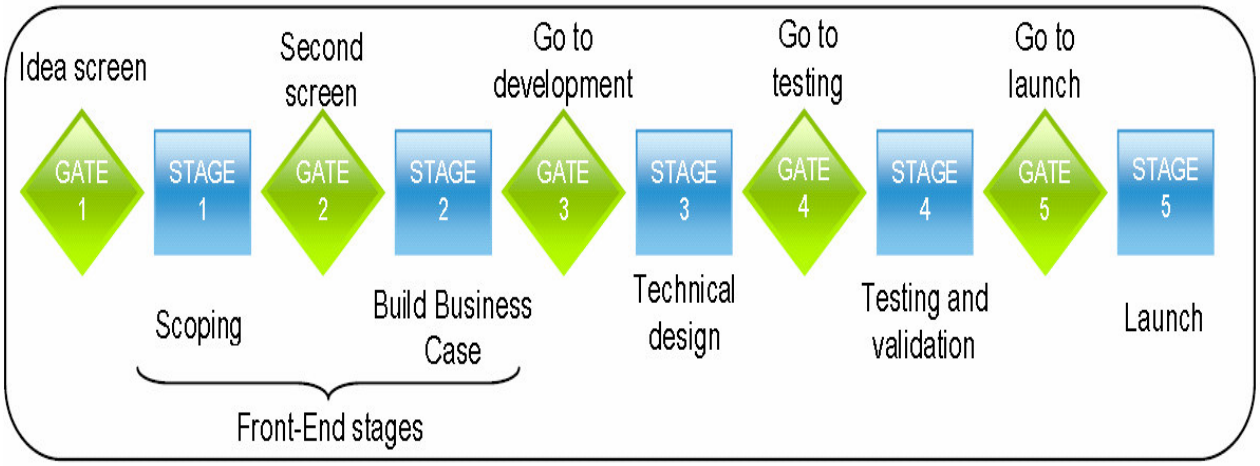

Figure 1. The stage-gate system model (source: Cooper, 2006).

commercial launching. The model of Cooper, called the Stage-Gate System is one of the most widely acknowledged systems (Rejeb et al., 2008). The Stage-Gate System model (Figure 1) divides the NPD into discrete stages, typically five stages. Each Stage gathers a set of activities to be done by a multifunctional project team. To enter into each stage, some conditions and criteria have to be fulfilled. These are specified in the Gates. A Gate is a project review in which all the information is confronted by the whole team. Some criticism of the method has surfaced, claiming that the steering group assessment in the stage and gate steps halts the project for an unnecessarily long time, making the process abrupt and discontinuous (Ottosson, 2004). A closer integration of management through virtual team in the process might be a solution for avoiding such situations.

Stage-gate process: This process is a method of managing the new product development process to increase the probability of launching new products quickly and successfully. The process provides a blueprint to move projects through the various stages of development: 1.) idea generation, 2.) preliminary investigation, 3.) business case preparation, 4.) product development, 5.) product testing, and 6.) product introduction. This process is used by such companies as IBM, Procter and Gamble, 3 M, General Motors, and others. The process is primarily used in the development of specific commercial products, and is more likely to be used in platform projects than in derivative projects.

Auto companies that have modified their Stage-Gates procedures are also significantly more likely to report (1) use of virtual teams; (2) adoption of collaborative and virtual new product development software supporting tools; (3) having formalized strategies in place specifically to guide the new product development process; and (4) having adopted structured processes used to guide the new product development process (Ettlie and Elsenbach, 2007).

DEMAND FOR MODIFIED STAGE-GATE WITH VIRTUAL PRODUCT DEVELOPMENT TEAM

Recently, the Stage-Gate system had been modified and adjusted to fitting the real situation in nowadays, called the Next Generation Stage-Gate (Figure 2). The greatest change in Stage-Gate system is that it has become a scalable process, scaled to fit very different types and risk-levels of projects, from very risky and complex platform developments through to lower risk extensions and modifications, and even to handle rather simple sales force requests.

Managers recognized that any kinds of product development project have to manage risks and consumption of resources, but it is not all necessary to go through the fulfil five-stage process. The process has revised into multiple versions to fit business needs and to accelerate projects. Stage-Gate XPress for projects of moderate risk, such as improvements, modifications and extensions; and Stage-Gate Lite for very small projects, such as simple customer requests (Cooper, 2008). Although Next Generation Stage-Gate has defined for different types and risk-levels of projects, but still team collaboration in each stage is unveiled. So dealing with virtual teams can bring an opportunity to make closer integration of team members in the process.

Virtual product development team by using collaborative tools can effectively be used both in the earlier and later stages of the NPD process. Past research has mainly focused on the role of Internet in NPD (Ozer, 2004). Almeida and Miguel (2007) have been identified in the literature that it seems to exist a lack of a conceptual model that represents all dimensions and interactions in the new product development process. On the other hand, some criticism of Stage-Gate method has surfaced, claiming that the steering group assessment in the gate

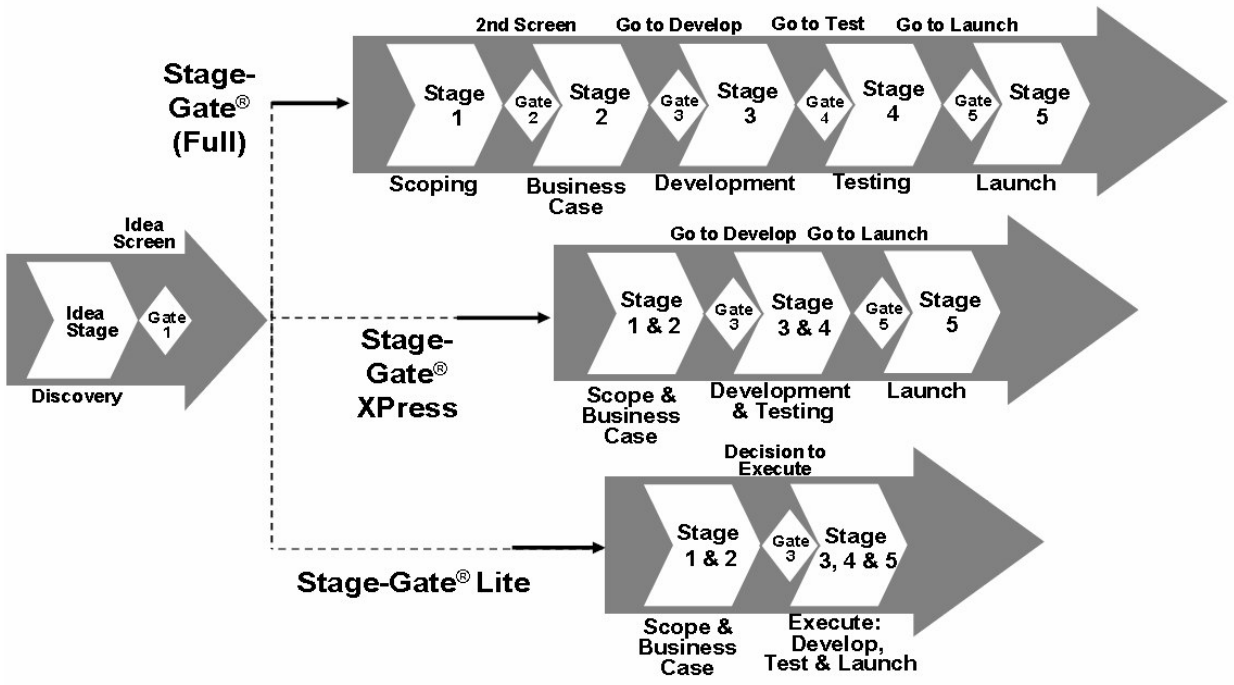

Figure 2. An overview of the next generation stag-gate (Source: (Cooper, 2008)).

step halts the project for an unnecessarily long time, making the process abrupt and discontinuous (Ottosson, 2004). A closer integration of management through virtual team in the process might be a solution for avoiding such situations. Integration is the essence of the concurrent product design and development activity in many organizations (Pawar and Sharifi, 1997). Ragatz et al. (2002) suggest that integration of the supplier's technology roadmaps into the development cycle is critical to ensuring that target costs are met.

To compensate for the lack of a conceptual model that represents all aspects and interactions in the new product process and decrease criticism of Stage-Gate system, a solution called Modified Stage-Gate system is introduced.

Figure 3 illustrates new model architecture of the virtual product development process. The architecture is structured in a two-layered framework: Traditional Stage-Gate system and collaborative tool layer which are supported by virtual team. Merge of Stage-gate system with virtual product development team lead to increased new product performance and decreased time-to-market. The following sections will describe some elements of the collaborative tool layer in more detail.

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel et al., 2005). We define, virtual team is small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks.

Capturing customer requirements

Collaborative tools allow firms to respond quickly to specific customer requirements with new, high-quality, innovative products, and it enables firms to build cross-functional competencies, enhance flexibility and share knowledge (Mulebeke and Zheng, 2006). Capturing customer requirements is represented throughout product development will facilitate performing quality function deployment (Rodriguez and Al-Ashaab, 2005).

Collaborative capabilities

Enabling collaborative capability through virtual teamwork represents a fundamental transitioning to be more effective organizational work practices (Susman et al., 2003). The use of virtual teams will change the communication pattern both within and outside the firm. Successful collaborations require more than the mere use of electronic communication and involve new skills and a supportive context that provides commitment and resources to facili-

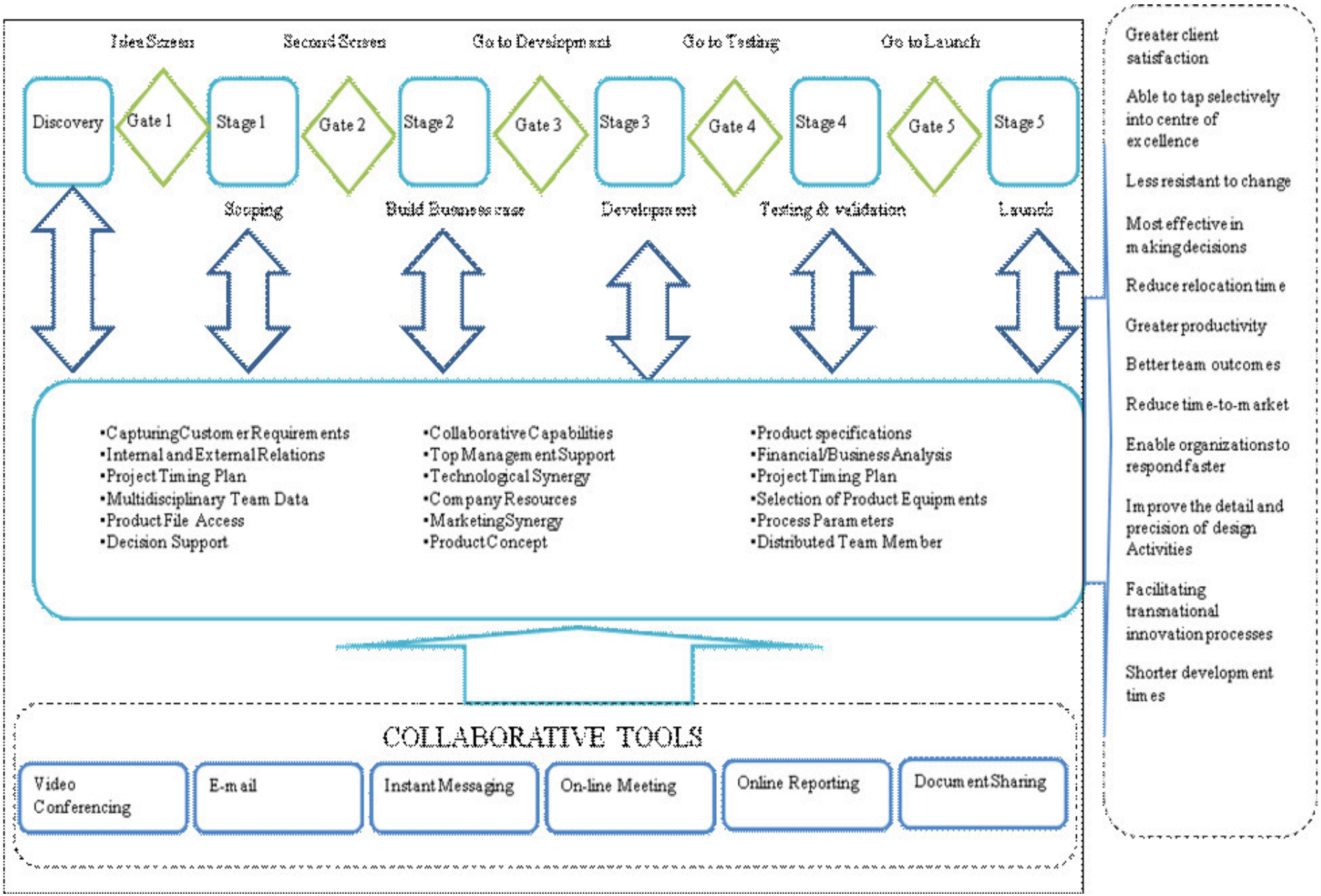

Figure 3. Modified stage-gate: model architecture of the virtual product development process.

tate collaboration (Martinez-Sanchez et al., 2006).

Company resources

Virtual team provides cost savings to employees by eliminating time-consuming commutes to central offices and offers employees more flexibility to co-ordinate their work and family responsibilities (Johnson et al., 2001). Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004) and able to digitally or electronically unite experts in highly specialized fields working at great distances from each other (Rosen et al., 2007).

Top management support is a strong motivational factor in the entire new product process. Although collaborative tools are able to assist top management but many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa and Leidner, 1999). Management commitment provides organizational support for change, generates enthusiasm, provides a clear vision of the product concept and assures sufficient allocation of resources (González and Palacios, 2002).

Information sharing has been identified as an important success factor in NPD (Ozer, 2006). The positive impact of information sharing on the success of new products has long been established in the NPD literature (Sridhar et al., 2007; Furst et al., 2004; Merali and Davies, 2001; Lipnack and Stamps, 2000).

Virtual teams reduce time-to-market (Sorli et al., 2006; Kankanhalli et al., 2006; Chen, 2008; Shachaf, 2008; Ge and Hu, 2008; Guniš et al., 2007). Lead time or time to market has been generally admitted to being one of the most important keys for success in manufacturing companies (Sorli et al., 2006). Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005). Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004) and reducing relocation time and costs, reduced travel costs (Bergiel et al., 2008; Fuller et al., 2006; Kankanhalli et al., 2006; Olson-Buchanan et al., 2007). Virtual NPD teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004). Virtual R&D team is able to tap selectively into a centre of excellence, using the best talent regardless of location (Criscuolo, 2005; Samarah et al., 2007; Fuller et al., 2006; Badrinarayanan and Arnett, 2008; Furst et al., 2004).

Virtual team also, respond quickly to changing business environments (Bergiel et al., 2008; Mulebeke and Zheng, 2006), able to digitally or electronically unite experts in highly specialized fields working at great distances from each other (Rosen et al., 2007), more effective R&D continuation decisions (Cummings and Teng, 2003; Schmidt et al., 2001), most effective in making decisions (Hossain and Wigand, 2004; Paul et al., 2004), provide greater degree of freedom to individuals involved with the development project (Ojasalo, 2008; Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002), Greater productivity, shorter development times (McDonough et al., 2001; Mulebeke and Zheng, 2006), Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources (Martins et al., 2004; Chen et al., 2008c; Rice et al., 2007), Useful for projects that require cross-functional or cross boundary skilled inputs (Lee-Kelley and Sankey, 2008), Less resistant to change (Precup et al., 2006), Facilitating transnational innovation processes (Gassmann and Von Zedtwitz, 2003; Prasad and Akhilesh, 2002), higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another) (Kratzer et al., 2005, Cascio, 2000; Gaudes et al., 2007), Evolving organizations from production-oriented to service/information-oriented (Johnson et al., 2001; Precup et al., 2006) and provide organizations with unprecedented level of flexibility and responsiveness (Hunsaker and Hunsaker, 2008; Chen, 2008; Pihkala et al., 1999; Liu and Liu, 2007). Beside these advantages virtual NPD teams are self-assessed performance and high performance (Chudoba et al., 2005; Poehler and Schumacher, 2007), employees perform their work without concern of space or time constraints (Lurey and Raisinghani, 2001), optimize the contributions of individual members toward the completion of business tasks and organizational goal (Samarah et al., 2007), reduce the pollution (Johnson et al., 2001), manage the development and commercialization tasks quite well (Chesbrough and Teece, 2002), Improve communication and coordination, and encourage the mutual sharing of inter-organizational resources and competencies (Chen et al., 2008a), employees can more easily accommodate both personal and professional lives (Cascio, 2000), cultivating and managing creativity (Leenders et al., 2003; Atuahene-Gima, 2003; Badrinarayanan and Arnett, 2008), facilitate knowledge capture and sharing knowledge, experiences (Rosen et al., 2007; Zakaria et al., 2004; Furst et al., 2004; Sridhar et al., 2007), Improve the detail and precision of design activities (Vaccaro et al., 2008), Provide a vehicle for global collaboration and coordination of R&D-related activities (Paul et al., 2005), Allow organizations to access the most qualified individuals for a particular job regardless of their location (Hunsaker and Hunsaker, 2008) and Enable organiza-tions to respond faster to increased competition (Hunsaker and Hunsaker, 2008; Pauleen, 2003).

The ratio of virtual R&D member publications exceeded from co-located publications (Ahuja et al., 2003) and the extent of informal exchange of information is minimal (Pawar and Sharifi, 1997, Schmidt et al., 2001). Virtual teams have better team outcomes (quality, productivity, and satisfaction) (Gaudes et al., 2007; Ortiz de Guinea et al., 2005; Piccoli et al., 2004), Reduce training expenses, Faster Learning (Pena-Mora et al., 2000, Atuahene-Gima,

2003; Badrinarayanan and Arnett, 2008) and finally greater client satisfaction (Jain and Sobek, 2006).

KEY FACTORS FOR SUCCESSFULLY IMPLEMENTING VIRTUAL TEAM IN NPD

NPD is continuing to be an area that is receiving increased attention, both in practice and academic spheres (Shani et al., 2003). Eppinger and Chitkara (2006) studied global product development (GPD) base on virtual teams, for companies in the manufacturing sector by conducting interviews with 30 executives and surveying over 1150 product development executives and professionals from large manufacturing companies. They reported the following ten key success factors for successful GPD:

- Management priority and commitment – Commitment from management to make the necessary organization, process and cultural changes to make GPD work.
- Process modularity for global distribution – Ability to separate activities into modular work packages for global distribution.
- Product modularity to develop subsystems or components in different locations – Ability to break down into subsystems for global distribution.
- Core competence so the company does not become completely reliant on suppliers or contractors – Good understanding of what the company's core competencies are, so that do not get outsourced.
- Intellectual property, which becomes more difficult to protect – Defining process and products in a modular way to protect IP.
- Data quality, which concerns availability, accessibility, and audit ability – Ability to update and share data with teams in multiple locations.
- Infrastructure (including networks and power supplies) to support activities in all locations – Unified infrastructure, systems, technologies, and processes that are shared between all locations.
- Governance and product management is needed to coordinate and monitor the entire effort – Ability to coordinate and monitor program, including detailed project planning.
- Collaborative culture is necessary and is helped by a consistent set of processes and standards – Building and sustaining trust, ensuring teams have consistent processes and standards.
- Organization change management requires planning, training, and education of those in key roles for global product development plan and train for new roles, behaviours, and skills.

Conclusion

The internet, incorporating computers and multimedia, have provided tremendous potential for remote integration and collaboration in business and manufacturing applications. Most companies today are divided in different departments located in different geographical places and dealing with specialized tasks. So using collaborative tools enables authorized users in geographically dispersed locations to have access to the company's product data and carry out product development work simultaneously and collaboratively on any operating systems.

The modified Stage-Gate system has demonstrated to be a good development platform for the NPD. In order to integrate and share the information and knowledge available within geographically distributed companies, this model can be a reference model. The proposed model architecture of a virtual product development process, does not aim to replace the existing systems in companies but rather to be a support tool for communicating and sharing knowledge among the disperse partners. Modified Stage-Gate system will lead to the production of better and more cost effective products, developed in a shorter period of time.

In highly competitive era which forces companies to launch a new product faster, the decision on setting up virtual teams and using a modified NPD process is not a choice but a requirement. The theme of virtual teams and application of a collaborative tool in NPD has not been much explored and researchers in this field are encouraging more studies and analyses to be made.

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Scientific Research and Essays Vol. 4 (13), pp. 1575-1590, December, 2009
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2009 Academic Journals

Standard Review

Virtual R & D teams in small and medium enterprises: A literature review

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Accepted 21 December, 2009

Small and medium enterprises (SMEs) are the driving engine behind economic growth. While SMEs play a critical role in generating employment and supporting trade, they face numerous challenges, the prominent among them are the need to respond to fasting time-to-market, low-cost and rapid solutions to complex organizational problems. Towards that end, research and development (R & D) aspect deserves particular attention to promote and facilitate the operations of SMEs. Virtual R & D team could be a viable option. However, literature shows that virtual R & D teaming in SMEs is still at its infancy. This article provides a comprehensive literature review on different aspects of virtual R & D teams collected from the reputed publications. The purpose of the state-of-the-art literature review is to provide an overview on the structure and dynamics of R & D collaboration in SMEs. Specifying the foundation and importance of virtual teams, the relationship between virtual R & D team and SMEs has been examined. It concludes with the identification of the gaps in the existing literatures and calls for future research. It is argued that setting-up an infrastructure for virtual R & D team in SMEs still requires a large amount of engineering efforts and deserves consideration at top level management.

Key words: Virtual teams, small and medium enterprises, literature review.

INTRODUCTION

SMEs are a major part of the industrial economies (Eikebrokk and Olsen, 2007; Robles-Estrada and Gomez-Suarez, 2007). Their survival and growth have therefore been a prominent issue. Beck et al. (2005) found that a strong and positive association between the growth of SMEs and GDP per capita growth. Their survival depended on their capability to market response, meeting performance and producing goods that could meet international standards (Gomez and Simpson, 2007). Organizations are currently facing unprecedented challenges in an ever dynamic, constantly changing and complex environment (Rezgui, 2007). It is urgent for SMEs to construct a network service platform to speed up the research and development process (Lan et al., 2004). ICTs are indispensible for SMEs to innovate (Redoli et al., 2008). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006).

Responding to the increasing de-centralization and globalization of work processes, many organizations have responded to their dynamic environments by introducing virtual teams. Virtual teams are growing in popularity (Wayne F. Cascio, 2000). Additionally, the rapid development of new communication technologies such as the Internet has accelerated this trend so that today, most of the large organizations employ virtual teams to some degree (Hertel, Geister and Konradt, 2005). Research on virtual teams is still in its nascent stages (Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002) and because of the relative newness of virtual teams, many areas of research have not been examined (Badrinarayanan and Arnett, 2008). Camarinha-Matos and Afsarmanesh (2003) conclude that, setting-up an infrastructure for virtual team still requires a large engineering effort, which represents a

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Abbreviations: SMEs, Small and medium enterprises; **R & D,** research and development; **ICTs,** information and computer technologies.

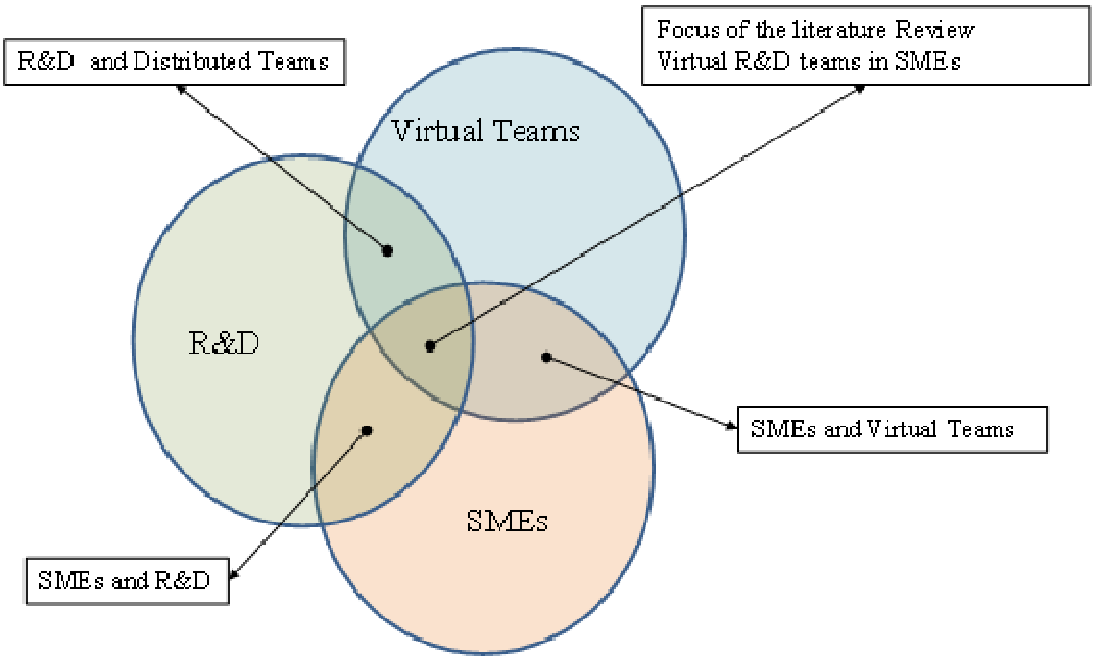

Figure 1. Literature fields included in the review - A general model.

major obstacle for the implantation of this new paradigm. Effective and efficient cooperation across disciplines and distributed teams becomes essential for the success of engineering projects (Zhang et al., 2008). Therefore, the experiments suggest that more research is needed to explore the ways to enhance the performance of virtual teams (El-Tayeh et al., 2008).

A small number of studies exclusively focused on the virtual R & D teams, for example (Gassmann and von Zedtwitz, 1999, 2003b; Kratzer et al., 2005; Tribe and Allen, 2003) and few of them concentrated on the virtual R & D teams in SMEs. This paper summarizes the key finding of precedent works on different aspects of virtual R & D teams in SMEs. It highlights the gaps and weaknesses in the existing literature on virtual R & D teams in SMEs. Finally, it identifies the future research directions in the area of concern.

LITERATURE SEARCH METHODOLOGY

Virtual R & D activities involving SMEs has not wide coverage. This review article is based on reliable and reputed publications that tried to accomplish the gaps. It mainly covers aspects like SMEs characteristics, scope of virtual R & D teams and their relationship with SMEs. The articles are collected from the following two sources:

1. Reputed journals, books and practitioners' literatures related to the topic published since 1997.
2. Research papers presented in a variety of conferences focusing on R & D and SMEs activities and technology management issues.

As there is no single definition of virtual R & D team in SMEs, there is a lack of specific research on the subject. A few studies have been done on virtual R & D teams in multinational companies. Hence, in order to find out structures, dynamics and management intervention in the field, a broader spectrum of literature has been considered. This review covered literatures in the areas of virtual R & D in general and its relevance with SMEs. The current understanding and thinking about SMEs and virtual R & D teams is found at the intersection of these separate fields, as illustrated in Figure 1.

The list of references contains approximately 194 items out of 537 selected items which were extracted from 1,425 pre-investigated items. To find relevant academic publications, some multidisciplinary databases were used. In order to find the relevancy a set of key words from a general model which is shown in Figure 1 were used. The general model for SMEs and virtual R & D teams enables a systematic integration of the fragmented literature on the topic. There is no consensus in the literature whether virtual teams are superior for SMEs or not. We argue that lack of SMEs will be sheltered by virtual teams.

The trend of publication shows that virtual R & D team in SMEs is an interesting topic in recent years. As an example, the distribution of published/citied articles per year extracted from Web of Science® data base is illustrated in Figure 2 to Figure 7.

VIRTUAL TEAMS: ORIGIN, TRENDS AND DEFINITION

While work teams were used in the U.S. as early as the

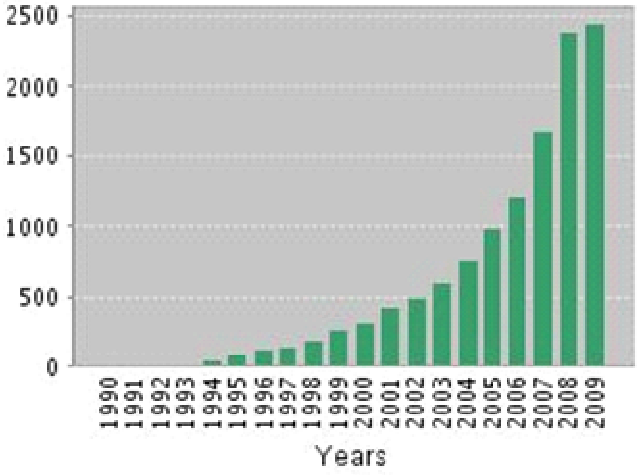

Figure 2. Citations trend of "SMEs" (Source Web of Science® (2009)).

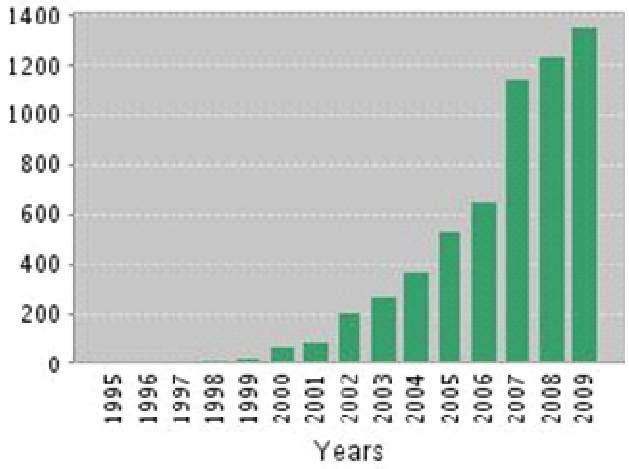

Figure 3. Citations trend of "Virtual teams" (Source Web of Science® (2009)).

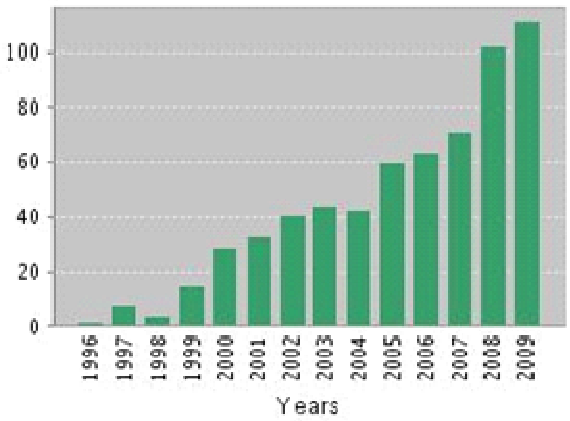

Figure 4. Citations trend of "SMEs and R & D" (Source Web of Science® (2009)).

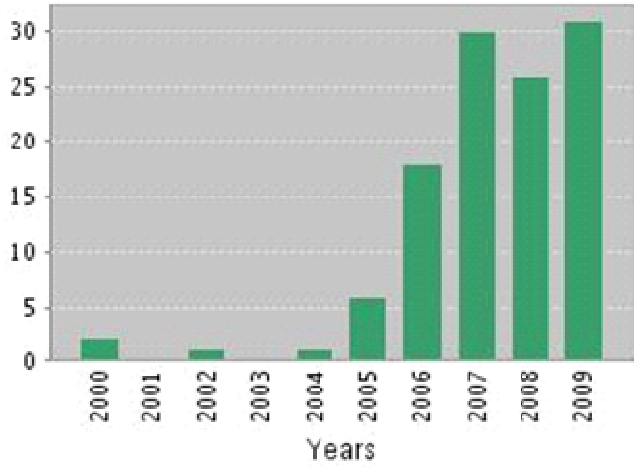

Figure 5. Citations trend of “R & D and Distributed Teams” (Source Web of Science® (2009)).

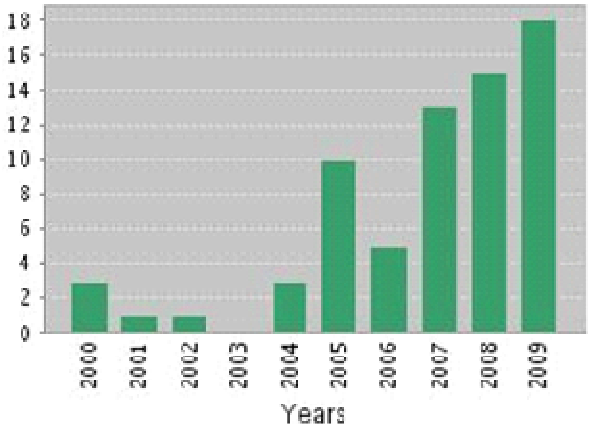

Figure 6. Citations trend of "Virtual R & D teams" (Source Web of Science® (2009)).

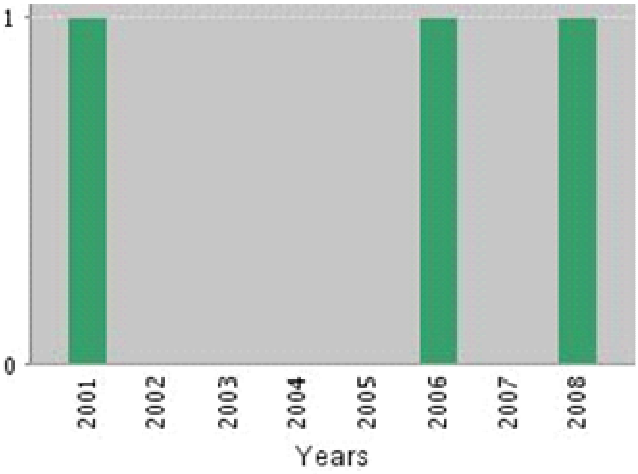

Figure 7. Article publications trend of "SMEs and Virtual R & D teams" (Source Web of Science® (2009)).

1960s, the widespread use of teams and quality circles began in the Total Quality Management movement of the 1980s. In the late 1980s and early 1990s, many companies implemented self-managing or empowered work teams. To cut bureaucracy, reduce cycle time and improve service, line-level employees took on decision-making and problem-solving responsibilities traditionally reserved for management. By the mid-1990s, increasing numbers of companies such as Goodyear, Motorola, Texas Instruments and General Electric had begun exporting the team concept to their foreign affiliates in Asia, Europe and Latin America to integrate global human resource practices (Kirkman et al., 2001). Now, due to communication technology improvements and continued globalization, virtual teams have increased rapidly worldwide (Kirkmann et al., 2002). This era is growing popularity for virtual team structures in organizations (Cascio, 2000; Walvoord et al., 2008). Martins et al. (2004) in a major review of the literature on virtual teams, conclude that 'with rare exceptions all organizational teams are virtual to some extent.' We have moved away from working with people who are in our visual proximity to working with people around the globe (Johnson et al., 2001).

Definition of Virtual Team

Literature related to virtual teams revealed a lack of depth in the definitions. Although virtual teamwork is a current topic in the literature on global organizations, it has been problematic to define what 'virtual' means across multiple institutional contexts (Chudoba et al., 2005). The concept of a "team" is described as a small number of people with complementary skills who are equally committed to a common purpose, goals and working approach for which they hold themselves mutually accountable (Zenun et al., 2007). It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Virtual teams are comprised of members who are located in more than one physical location. This team trait has fostered an extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007).

Gassmann and Von Zedtwitz (2003b) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose pose and work across links strengthened by information, communication and transport technologies." Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work, predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel et al., 2005), different authors have identified diverse. From the perspective of Leenders et al. (2003), virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Lurey and Raisinghani (2001) defined virtual teams - groups of people who work together although they are often dispersed across space, time and/or organizational boundaries. Amongst the different definitions of the concept of a virtual team the following form is one of the most widely accepted: (Powell et al., 2004), ''we define virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks''.

The degree of geographic dispersion within a virtual team can vary widely from having one member located in a different location than the rest of the team to having each member located in a different country (Staples and Zhao, 2006). Along with Bal and Teo (2001) it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized (Lee-Kelley and Sankey, 2008) although (Bal and Teo, 2001; Paul et al., 2005; Wong and Burton, 2000) included 'temporary' in virtual team definition but some authors like Gassmann and Von Zedtwitz (2003b) use, 'may be temporary' for some team members.

A summary of the definition of a virtual team may be taken as: small temporary groups of geographically, organizationally and/ or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks.

Advantages and disadvantages of virtual teams

During the last decade, words such as "virtual", "virtualization", "virtualized" have been very often advocated by scholars and practitioners in the discussion of social and economic issues (Vaccaro et al., 2008) but the advantages and pitfalls of a virtual team is concealed. The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. Anderson et al. (2007) suggest that the effective use of communication, especially during the early stages of the team's development, plays an equally important role in gaining and maintaining trust. Virtual team may allow people to collaborate with more productivity at a distance (Gassmann and Von Zedtwitz, 2003a). As a drawback,

Table 1. Common criteria of virtual team.

Characteristics of virtual team	Descriptions	References
Common criteria	Geographically dispersed (over different time zones)	(Dafoulas and Macaulay, 2002; Lee-Kelley and Sankey, 2008; Nemiro, 2002; Peters and Manz, 2007; Shin, 2005; Wong and Burton, 2000).
	Driven by common purpose (guided by a common purpose)	(Bal and Teo, 2001; Gassmann and Von Zedtwitz, 2003b; Hertel et al., 2005; Rezgui, 2007; Shin, 2005).
	Enabled by communication technologies	(Bal and Teo, 2001; Lee-Kelley and Sankey, 2008; Nemiro, 2002; Peters and Manz, 2007)
	Involved in cross-boundary collaboration	(Bal and Teo, 2001; Gassmann and Von Zedtwitz, 2003b; Precup et al., 2006; Rezgui, 2007).
Other characteristics	It is not a permanent team	(Bal and Teo, 2001; Cascio and Shurygailo, 2003; Leenders et al., 2003; Paul et al., 2005; Wong and Burton, 2000).
	Small team size	(Bal and Teo, 2001).
	Team member is knowledge workers	(Bal and Teo, 2001; Kirkman et al., 2004).
	Team members may belong to different companies	(Dafoulas and Macaulay, 2002; Leenders et al., 2003).

virtual teams are particularly weak at mistrust, communication break downs, conflicts and power struggles (Rosen et al., 2007). On the other hand, virtual teams reduce time-to-market (May and Carter, 2001). Lead Time or Time to market has been generally admitted to being one of the most important keys for success in manufacturing companies (Sorli et al., 2006). Table 2 summarizes some of the main advantages and Table 3 some of the main disadvantages associated with virtual teaming. Finally, organizational and cultural barriers are another serious impediment to the effectiveness of virtual teams. Many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa and Leidner, 1999).

Forming and performing in virtual teams is useful for projects that require cross-functional or cross boundary skilled inputs and the key to their value creation is to have a defined strategy in place to overcome the issues highlighted, especially the time zones and cultural issues. While communication could be seen as a traditional team issue, the problem is magnified by distance, cultural diversity and language or accent difficulties. For migration or similar large-scale projects, personal project management competency, appropriate use of technology and networking ability, willingness for self-management, cultural and interpersonal awareness is the fundamentals of a successful virtual team (Lee-Kelley and Sankey, 2008).Thomas and Bostrom (2005) found that a technology facilitator role can be critically important to virtual team success.

RESEARCH AND DEVELOPMENT (R & D) AND DISTRIBUTED TEAM

Nowadays, unpredictable economic and business environment suggests that many firms seek new ways of conducting their business through some kind of innovation to make a profit and stay ahead of the competition (Laforet, 2007). Around the world, innovation is now recognized as a prime source of competitive advantage (Hegde and Hicks, 2008). Research and development is a strategy for developing technologies that can be commercialized under independent intellectual property rights. R & D enables firms to create new technologies and/ or to build on existing technologies obtained through technology transfer (Zhouying, 2005). R & D activities are now dependent to different location drivers (von Zedtwitz and Gassmann, 2002). Many firms started to acquire their knowledge from external sources (Erkena and Gilsing, 2005). R & D units in foreign countries have gained more responsibilities and competencies besides the still-existing traditional mode of product developed

Table 2. Some of the main advantages associated with virtual teaming.

Advantages	References
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space and organizational affiliation that traditional teams face (Piccoli, Powell and Ives, 2004))	(Bergiel et al., 2008; Biuk-Aghai, 2003; Boudreau et al., 1998; Cascio, 2000; Kankanhalli et al., 2006; Lipnack and Stamps, 2000; Liu and Liu, 2007; McDonough et al., 2001; Olson-Buchanan et al., 2007; Prasad and Akhilesh, 2002; Rice et al., 2007).
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005)]	(Chen, 2008; Ge and Hu, 2008; Gunis et al., 2007; Kankanhalli et al., 2006; Kusar et al., 2004; Lipnack and Stamps, 2000; May and Carter, 2001; Mulebeke and Zheng, 2006; Prasad and Akhilesh, 2002; Shachaf, 2008; Sorli et al., 2006; Sridhar et al., 2007; Zhang et al., 2004).
More effective R & D continuation decisions	(Cummings and Teng, 2003; Schmidt et al., 2001).
Most effective and rapid in making decisions	(Bal and Gundry, 1999; Hossain and Wigand, 2004; Paul et al., 2004).
Able to tap selectively into the center of excellence, using the best talent regardless of location	(Badrinarayanan and Arnett, 2008; Boudreau et al., 1998; Boutellier et al., 1998; Cascio, 2000; Criscuolo, 2005; Fuller et al., 2006; Furst et al., 2004; Prasad and Akhilesh, 2002; Samarah et al., 2007).
Greater degree of freedom to individuals involved with the development project	(Badrinarayanan and Arnett, 2008; Ojasalo, 2008; Prasad and Akhilesh, 2002).
Greater productivity, shorter development times	(McDonough et al., 2001; Mulebeke and Zheng, 2006).
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	(Chen et al., 2008; Martins et al., 2004; Rice et al., 2007).
Useful for projects that require cross-functional or cross boundary skilled inputs	(Lee-Kelley and Sankey, 2008).
Higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another)	(Cascio, 2000; Gaudes et al., 2007; Kratzer et al., 2005).
Provide organizations with the unprecedented level of flexibility and responsiveness	(Chen, 2008; Gunis et al., 2007; Hunsaker and Hunsaker, 2008; Liu and Liu, 2007; Piccoli et al., 2004; Pihkala et al., 1999; Powell et al., 2004; Prasad and Akhilesh, 2002).
Self-assessed performance and high performance.	(Chudoba et al., 2005; Poehler and Schumacher, 2007).
The extent of informal exchange of information is minimal (virtual teams tend to be the more task oriented and exchange less socio emotional information	(Pawar and Sharifi, 1997; Schmidt et al., 2001).
Respond quickly to changing business environments	(Bergiel et al., 2008; Mulebeke and Zheng, 2006).
Improve communication and coordination and encourage the mutual sharing of inter-organizational resources and competencies	(Chen et al., 2008).
Sharing knowledge, experiences; Facilitate knowledge capture	(Furst et al., 2004; Lipnack and Stamps, 2000; Merali and Davies, 2001; Rosen et al., 2007; Sridhar et al., 2007; Zakaria et al., 2004).

Table 2. Contd.

Provide a vehicle for global collaboration and coordination of R & D-related activities	(Paul et al., 2005).
Enable organizations to respond faster to increased competition	(Hunsaker and Hunsaker, 2008; Pauleen, 2003).
Better team outcomes (quality, productivity and satisfaction)	(Gaudes et al., 2007; Ortiz de Guinea et al., 2005; Piccoli et al., 2004).
Higher team effectiveness and efficiency	(May and Carter, 2001; Shachaf and Hara, 2005).

Table 3. Some of the main disadvantages associated with virtual teaming.

Disadvantages	References
Sometimes requires complex technological applications	(Badrinarayanan and Arnett, 2008; Bergiel et al., 2008)
Decrease monitoring and control of activities	(Pawar and Sharifi, 1997).
Weak at mistrust, communication break downs, conflicts and power struggles	(Baskerville and Nandhakumar, 2007; Cascio, 2000; Kirkman et al., 2002; Rosen et al., 2007; Taifi, 2007).
Challenges of project management are more related to the distance between team members than to their cultural or language differences	(Badrinarayanan and Arnett, 2008; Jacobsa et al., 2005; Martinez-Sanchez et al., 2006; Wong and Burton, 2000).
Challenges of determining the appropriate task technology fit	(Badrinarayanan and Arnett, 2008; Bell and Kozlowski, 2002; Griffith et al., 2003; Ocker and Fjermestad, 2008; Pawar and Sharifi, 2000; Qureshi and Vogel, 2001).
Challenges of managing conflict	(Hinds and Mortensen, 2005; Kayworth and Leidner, 2002; Ocker and Fjermestad, 2008; Piccoli et al., 2004; Ramayah et al., 2003; Wong and Burton, 2000).
Cultural and functional diversity in virtual teams leads to differences in the members' thought processes. Develop trust among the members are challenging	(Badrinarayanan and Arnett, 2008; Bell and Kozlowski, 2002; Boutellier et al., 1998; Griffith et al., 2003; Jacobsa et al., 2005; Kankanhalli et al., 2006; Munkvold and Zigurs, 2007; Paul et al., 2005; Poehler and Schumacher, 2007; Shachaf, 2005).

adapted in the home country and technical support for production in abroad (Reger, 2004). Trends in the last decade has shown China and India emerging as attractive R & D destinations for the USA (Hegde and Hicks, 2008).

Changes in telecommunications and data processing capabilities make it possible to coordinate research, marketing and production operation around the world (Acs and Preston, 1997). Hegde and Hicks (Hegde and Hicks, 2008) noted that overseas R & D sites are auxiliary outposts, subservient to home R & D laboratories. "Corporate growth and positioning" and "knowledge sourcing" are two forces which result in companies with a more global R & D nature (Richtne´r and Rognes, 2008). Technological change is a highly dynamic process that may quickly relocate to take the advantage of optimum conditions for growth (Hegde and Hicks, 2008). For most R & D teams', being virtual is a matter of degree (Leenders et al., 2003).

SMEs: DEFINITION, IMPORTANCE AND MAJOR CHARACTERISTICS

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from

country to country (O'Regan and Ghobadian, 2004). Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition for SMEs (Deros et al., 2006). Table 4 illustrate the definition of SMEs in some selected countries..In the absence of a definitive classification, a consensus has developed around the European Commission (EC) criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria, employee numbers (up to 250 employees), turnover and balance sheet statistics (Tiwari and Buse, 2007). While turnover and balance sheet statistics are part of the criteria, the overriding consi-deration in practice appears to be employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small to medium-sized firm.

The importance of Small and medium size enterprises (SMEs)

Small and Medium Enterprises (SMEs) play an important role to promote economic development. Acs et al. (1997) concluded that small firms are indeed the engines of global economic growth. In most countries, SMEs dominate the industrial and commercial infrastructure (Deros et al., 2006). More importantly, SMEs play an important role in flows of foreign direct investment (FDI) (Kuo and Li, 2003). Economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance (Schroder, 2006). In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003). China's recent rapid growth is also linked to the emergence of many new small firms in village townships and in coastal areas, often named new industries (Acs et al., 1997).

To survive in the global economy SMEs have to improve their products and processes exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). Hanna and Walsh (2002) observed that if small firms want to make a step-change in their technological and innovation base, they have to rethink their approach to cooperation. SMEs need appropriate and up-to-date knowledge in order to compete and there is a strong need to create, share and disseminate knowledge within SME's (Nunes et al., 2006). Especially, in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development (Blomqvist et al., 2004). The key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing processes (Rosen et al., 2007). Dickson and Hadji-manolis (Dickson and Hadjimanolis, 1998) examined innovation and networking among small manufacturing companies. They found some tentative evidence that companies operating in terms of "the local strategic network" are more innovative than those operating in terms of "the local self-sufficiency". In the beginning of R & D activities, SMEs always face capital shortage and need technological assistance.

Most firms today do not operate alone; they are networked vertically with many value-chain partners (Miles et al., 2000). The typical Taiwanese production system has a cooperative network of SMEs that are extremely flexible and quick responsive, although under-capitalized and sensitive to market demand and highly integrated in the global economy (Low, 2006). Strategic alliance formation mechanism has been touted as one of the most critical strategic actions that SMEs must undertake for survival and success (Dickson et al., 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets, but more in those areas such as R & D that will directly generate their future competitive advantage.

The major characteristics of SMEs

In order to have a better understanding of SMEs behavior, a brief knowledge of the characteristics of SMEs is a must and therefore the major characteristics of SMEs are listed in Tables 5 and 6 (these are for all types of SMEs and not all may hold true for every SME). SMEs are not scaled-down versions of large companies. There are different characteristics that distinguish them from large corporations and that can, of course, change across different countries and cultures. SMEs are generally independent, multi-tasking, cash-limited and owner-based actively managed by the owners, highly personalized and informal structured, largely localized enterprises in their area of operations that are largely dependent on internal sources to the growth of finance (Perrini et al., 2007).

VIRTUAL R & D TEAMS IN SMES

Most SMEs are heavily reliant on external sources, including customers and suppliers, for the generation of new knowledge (Jones and Macpherson, 2006). SMEs of all sizes must reach out into their external environment for necessary resources (P. H. Dickson et al., 2006). In the present era of globalization, it is obvious that the survival of the SMEs will be determined first and foremost

Table 4. Definition of SMEs in Selected countries.

Country	Category of enterprise	Employee numbers	Turnover	Other measures	Source
European Commission	Small	10 - 50 employees	Less than € 10 million turnover	Balance sheet total :Less than € 10 million balance sheet total	(Fathian et al., 2008).
	Medium	Fewer than 250 employees	Less than € 50 million turnover	Balance sheet total :Less than € 43 million balance sheet total	(Fathian et al., 2008).
Japan		Up to 300 employees		¥100 million assets	(Deros et al., 2006).
Indonesia	Small	5 - 19		annual value of sales of a maximum of IDR1 billion (USD100,000)	(APO, 2007).
	Medium	20 - 99		annual value of sales of more than IDR1 billion but less than IDR50 billion	(APO, 2007).
Iran	Small	Less than 10* Less than 50**			*(CBI, 2009). **(ISIPO, 2009).
	Medium	10 - 100* 50 - 250**			*(CBI, 2009). **(ISIPO, 2009).
Malaysia	Small	Between 5 and 50 employees	Between RM 250,000 and less than RM 10 million		(NSDC, 2005).
	Medium	51 - 150 employees	Between RM 10 million and RM 25 million		(NSDC, 2005).
Philippines	Small	10 - 99 employees.		Between PHP 3-15 million asset	(APO, 2007)
	Medium	100 - 199 employees.		Between PHP 15-100 million asset	(APO, 2007)
South Korea		Up to 300 employees			(Oh, Cruickshank and Anderson, 2009)
Tanzania	Small	5 - 50	150.0 million (Tshs)	Capital invested: 5.1-200.0 million(Tshs)	(Mahemba and Bruijn, 2003)
	Medium	51 - 100	300.0million (Tshs) Tshs = US$ 1.050 (2003)	Capital invested: 201-800.0 million(Tshs)	(Mahemba and Bruijn, 2003)
USA		fewer than 500		stand-alone enterprises	(Deros et al., 2006)

Table 5. Some of the major advantages of SMEs.

Advantages	References
Able to respond quickly to customer requests and market changes, customers focused	(Abdul-Nour et al., 1999; Canavesio and Martinez, 2007; Huang et al., 2004; Jones and Macpherson, 2006; Levy and Powell, 1998; Mahemba and Bruijn, 2003; Schatz, 2006; Wu et al., 2007).
Flexible and fast-response to change, easily adaptive to new market conditions, dynamic in behavior, developing customized solutions for partners and customers	(Abdul-Nour et al., 1999; Aragon-Sanchez and Sanchez-Marín, 2005; Davis and Sun, 2006; Deros et al., 2006; Levy and Powell, 1998; Mezgar et al., 2000; Narula, 2004; Nieto and Fernandez, 2005; Sarosa, 2007; Schatz, 2006; Starbek and Grum, 2002).
Quick decision making process (decisions are made by an individual or a small number of people, or a single individual)	(Axelson, 2005; Deros et al., 2006; Lawson et al., 2006; Schatz, 2006).
Strongly correlated and inter-related with respect to innovation and entrepreneurship	(Bodorick et al., 2002; Chew and Yeung, 2001; Gray, 2006; Gunasekaran et al., 1999; Huang et al., 2001; Robles-Estrada and Gomez-Suarez, 2007; Sharma and Bhagwat, 2006)
More extensive use of external linkages for Innovate.	(Barnett and Storey, 2000; Hoffman et al., 1998; Laforet and Tann, 2006).
Nonbureaucratic processes, flat and flexible structures	(Axelson, 2005, 2007; Deros et al., 2006; Haga, 2005; Levy and Powell, 1998; Massa and Testa, 2008; Schatz, 2006; Sharma and Bhagwat, 2006).
Strong inter and intra-firm relationships, managing a great amount of information	(Carbonara, 2005; Chen et al., 2007).
Good at multi-tasking	(Axelson, 2007; Schatz, 2006).
Capable of going international early and rapidly	(Gassmann and Keupp, 2007).
Productive	(Beck et al., 2005).
Knowledge creating	(Egbu et al., 2005; Levy et al., 2003).
Creating astute alliances, networking	(Dijk et al., 1997; Karaev et al., 2007; Kearney and Abdul-Nour, 2004; Massa and Testa, 2008; Partanen et al., 2008)

by their ability to manufacture and supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources (Sharma and Bhagwat, 2006). In order to face this challenge, SMEs can reinforce knowledge to create synergies that allow firms to overcome difficulties and succeed. This may lead to new relationships between different agents to overcome scarcity and/or difficulties in gaining access to resources (Gomez and Simpson, 2007).

The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtual invention (Miles et al., 2000). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). Sharma and Bhagwat (2006) study results revealed that information technology (IT) in SMEs is still in a backseat despite the fact that use of computers is continuously increasing in their operations.

Call for Virtual R & D Teams in SMEs

A global market requires a short R & D cycle; hence SMEs are also forced into shifting from sequential to concurrent product development. Virtual teams are dra-

Table 6. Some of the major disadvantages of SMEs.

Disadvantages	References
Scarce resources and manpower	(Abdul-Nour et al., 1999; Axelson, 2007; Caputo et al., 2002; Jansson and Sandberg, 2008; Kearney and Abdul-Nour, 2004; Kim et al., 2008; Lu and Beamish, 2006; Nieto and Fernandez, 2005; Partanen et al., 2008; Wang and Chou, 2008; Yusuff et al., 2005).
Limited degree of information technology (IT) implementation	(Egbu et al., 2005; Eikebrokk and Olsen, 2007; Lin et al., 2007; Sarosa and Zowghi, 2003; Sharma and Bhagwat, 2006; Wang and Chou, 2008).
Weak at converting research and development into effective innovation	(O'Regan et al., 2006).
Lacking some of the essential resources for innovation and severe resource limitations in R & D	(Dickson and Hadjimanolis, 1998; Hausman, 2005; Lee and Ging, 2007; Massa and Testa, 2008; Rolfo and Calabrese, 2003; Sharma and Bhagwat, 2006; Singh et al., 2008).
Not having formal R & D activities	(Adams et al., 2006; Bougrain and Haudeville, 2002).
Strategy formulation on the basis of what available, lack a long run perspective	(Gomez and Simpson, 2007; Lindman, 2002; Yusuff et al., 2005).
Lagging in the export, lack the resources necessary to enter foreign markets	(Jansson and Sandberg, 2008; Mahajar et al., 2006).
Lack of industrial engineers or right kind of manpower to apply various statistical and managerial methods or tools	(Ahmed and Hassan, 2003)

matically influencing organizations and employee virtual R & D in SMEs is not a choice but an obligation to reduce the time-to-market in the intensively competitive market environment. Along with the findings of Gassmann and Keupp (2007), advantages of virtual teams for SMEs are extracted and illustrated in Table 7. Managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage such as R & D. Therefore, managers of SMEs should recognize that virtual teams are essential in modern organizations.

CONCLUSION

This paper is providing a comprehensive review on virtual R & D teams in SMEs in an effort to assess the state of the literature. Information and communication technology, although now is very popular but still not matured enough, so dealing with it can generate new findings. Currently, the topic suffers from limitation of coverage in almost all major publications as it is obvious in Figure 7. Although Virtual teams in SMEs can enhance the competitive flexibility of organizations, there are still considerable gaps in virtual R & D team efforts and effects within SMEs. A comprehensive empirical study would now seem to be important. Such a study would provide an assessment on patterns, practices, technology or types of activities that should be carried out by R & D virtual teams in SME's. It can further go into the probable and possible benefits and problems that arise as a consequence of the creation of virtual R & D team in SMEs.

While some studies have been conducted on usage of the certain model in large companies, applications within SMEs have still remained largely un-documented. This extensive review shows that limited work has been directed towards exploring and analyzing the existing inter-relation between virtual R & D teams and SMEs. Therefore empirical research on this important new type of team working shows tremendous promise for future research. Keeping virtual R & D teams in SMEs, operating innovatively, effectively and efficiently, is of a high importance, but the issue has poorly been addressed simultaneously in the previous studies. In many cases, virtual R & D teams can be used as an optional strategy for compensating the lack of resources among SMEs.

Managing virtual R & D teams in SMEs is a challenge. Some important challenges are development of trust

Table 7. Compensate lack of SMEs by virtual teams.

Disadvantage of SMEs	Can be compensated with advantage of virtual teams
Scarce resources and manpower	Able to tap selectively into the center of excellence, using the best talent regardless of location Reducing relocation time and costs, reduced travel costs Reducing time-to-market (Time has an 1:1 correlation with cost)
Lacking some of the essential resources for innovation, severe resource limitations in R & D Not having formal R & D activities limited degree of information technology (IT) implementation	More effective R & D continuation decisions Can manage the development and commercialization tasks quite well Sharing knowledge, experiences
Weak at converting research and development into effective innovation	Facilitating transnational innovation processes Higher team effectiveness and efficiency
Rely on outdated technology, labor intensive and traditional management practices	Respond quickly to changing business environments Most effective in making decisions Provide organizations with the unprecedented level of flexi-bility and responsiveness
Lagging in the export	Provide a vehicle for global collaboration and coordination of R & D-related activities

between team members, determining the appropriate task technology fit and establishing proper tools and systems to facilitate information sharing. Effective management can help a virtual R & D teams in SMEs to overcome the constraints imposed by applying virtual R & D team. Therefore, setting-up an infrastructure for virtual R & D team in SMEs still requires a large amount of engineering efforts, especially designing a proper collaborative system. Successful management of virtual teams requires new methods of supervision. Extensive research is needed to understand the characteristics of virtual R & D teams in SMEs. We believe our work provides a further step in this direction.

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Australian Journal of Basic and Applied Sciences, 3(3): 2653-2669, 2009
ISSN 1991-8178

Virtual Teams: a Literature Review

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Abstract: In the competitive market, virtual teams represent a growing response to the need for fasting time-to-market, low-cost and rapid solutions to complex organizational problems. Virtual teams enable organizations to pool the talents and expertise of employees and non-employees by eliminating time and space barriers. Nowadays companies are heavily investing in virtual team to enhance their performance and competitiveness. Despite virtual team growing prevalence, relatively little is known about this new form of team. Hence the study offers an extensive literature review with definitions of virtual teams and a structured analysis of the present body of knowledge of virtual teams. First, we distinguish virtual teams from conventional teams, different types of virtual teams to identify where current knowledge applies. Second, we distinguish what is needed for effective virtual team considering the people, process and technology point of view and underlying characteristics of virtual teams and challenges the entail. Finally we have identified and extended 12 key factors that need to be considered, and describes a methodology focused on supporting virtual team working, with a new approach that has not been specifically addressed in the existing literature and some guide line for future research extracted.

Key words: *Virtual team, Literature review, Effective virtual team,*

INTRODUCTION

Research on virtual teams is still in its nascent stages (Badrinarayanan and Arnett, 2008, Prasad and Akhilesh, 2002) and because of the relative newness of virtual teams, many areas of research have not been examined (Badrinarayanan and Arnett, 2008). Camarinha-Matos and Afsarmanesh (2003) conclude that, setting-up an infrastructure for virtual team still requires a large engineering effort, which represents a major obstacle for the implantation of this new paradigm. Effective and efficient cooperation across disciplines and distributed teams becomes essential for the success of engineering projects (Zhang *et al*., 2008). Therefore the experiments suggest that more research is needed to explore the ways to enhance the performance of virtual teams (El-Tayeh *et al*., 2008).

Organizations are currently facing important and unprecedented challenges in an ever dynamic, constantly changing and complex environment (Rezgui, 2007). Economic activity of all types is moving in the direction of globalization (Acs and Preston, 1997). Zhouying (2005) supports, the economic and technological gap between developed and developing countries can largely be explained by the gaps in the levels of soft technology and soft environments between the two sets of countries. As a result this matter should taking into account. With the rapid development of electronic information and communication media in the last decades, distributed work has become much easier, faster and more efficient (Hertel *et al*., 2005). Responding to the increasing de-centralization and globalization of work processes, many organizations have responded to their dynamic environments by introducing virtual teams that collaborate by communication technologies across geographical, temporal, cultural and organizational boundaries to achieve common goal in their organizations outputs. Virtual teams are growing in popularity (Cascio, 2000). Additionally, the rapid development of new communication technologies such as the internet has accelerated this trend so that today, most of the larger organization employs virtual teams to some degree (Hertel *et al*., 2005). Information technology is providing the infrastructure necessary to support the development of new organization forms. Virtual teams represent one such organizational form, one that could revolutionize the workplace and provide organizations with unprecedented level of flexibility and responsiveness (Powell *et al*., 2004). Virtual teams are important mechanisms for organizations seeking to leverage scarce resources across geographic and other boundaries

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(Munkvold and Zigurs, 2007). Now complex products are designed much more collaboratively with the suppliers being involved in the design process. The production of a new car for example involves different companies in the supply chain acting more as partners in a joint manufacturing exercise (Anderson *et al*., 2007). However by comparison in today's competitive global economy, organizations capable of rapidly creating virtual teams of talented people can respond quickly to changing business environments. capabilities of this type offer organizations a form of competitive advantage (Bergiel *et al*., 2008). Virtual teams represent a large pool of new product know-how which seems to be a promising source of innovation. At present, except for open source software, little is known about how to utilize this know-how for new product development (Fuller *et al*., 2006a).

The main sections of the paper will discuss the findings from the literature survey in a number of areas. There are sections discussing what virtual team is, definitions, types, examples, benefits and drawbacks, virtual teams and its benefits and drawbacks. Last sections provide the basis for a summing up section describing what are effective virtual team and a number of key challenges that are now faced. The next section discusses the definition of virtual team.

What Is Virtual Team?

Virtual Teams: Origins and Trends:

While work teams were used in the U.S. as early as the 1960s, the widespread use of teams and quality circles began in the Total Quality Management movement of the 1980s. In the late 1980s and early 1990s, many companies implemented self-managing or empowered work teams. To cut bureaucracy, reduce cycle time, and improve service, line-level employees took on decision-making and problem-solving responsibilities traditionally reserved for management. By the mid-1990s, increasing numbers of companies such as Goodyear, Motorola, Texas Instruments, and General Electric had begun exporting the team concept to their foreign affiliates in Asia, Europe, and Latin America to integrate global human resource practices (Kirkman *et al*., 2001). Now, due to communication technology improvements and continued globalization, virtual teams have increased rapidly worldwide (Kirkman *et al*., 2002). This era is growing popularity for virtual team structures in organizations (Walvoord *et al*., 2008, Cascio, 2000). Martins *et al*. (2004) in a major review of the literature on virtual teams, conclude that 'with rare exceptions all organizational teams are virtual to some extent. We have moved away from working with people who are in our visual proximity to working with people around the globe (Johnson *et al*., 2001).

Definition of Virtual Team:

Literature related to virtual teams revealed a lack of depth in the definitions. Although virtual teamwork is a current topic in the literature on global organizations, it has been problematic to define what 'virtual' means across multiple institutional contexts (Chudoba *et al*., 2005). The concept of a "team" is described as a small number of people with complementary skills who are equally committed to a common purpose, goals, and working approach for which they hold themselves mutually accountable (Zenun *et al*., 2007). It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson *et al*., 2007). Virtual teams are comprised of members who are located in more than one physical location. This team trait has fostered extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007).

Gassmann and Von Zedtwitz (2003b) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies. Another definition suggests that virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel *et al*., 2005), different authors have identified diverse. From the perspective of Leenders *et al*. (2003) virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Lurey and Raisinghani (2001) defined virtual teams - groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries. Amongst the different definitions of the concept of a virtual team the following from is one of the most widely accepted: (Powell *et al*., 2004), ''we define virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks''.

The degree of geographic dispersion within a virtual team can vary widely from having one member located in a different location than the rest of the team to having each member located in a different country (Staples and Zhao, 2006). Along with Bal and Teo (2001a) it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized (Lee-Kelley and Sankey, 2008) although (Bal and Teo, 2001a, Paul *et al*., 2005, Wong and Burton, 2000) included temporary in virtual team definition but some authors like Gassmann and Von Zedtwitz (2003b) use may be temporary for some team members.

Table 1: Common criteria of virtual team

Characteristics of virtual team	Descriptions	References
Common criteria	Geographically dispersed (over different time zones)	(Dafoulas and Macaulay, 2002, Shin, 2005, Wong and Burton, 2000, Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008)
	Driven by common purpose (guided by a common purpose)	(Bal and Teo, 2001a, Shin, 2005, Hertel *et al*., 2005, Gassmann and Von Zedtwitz, 2003b, Rezgui, 2007)
	Enabled by communication technologies	(Bal and Teo, 2001a, Nemiro, 2002, Peters and Manz, 2007, Lee-Kelley and Sankey, 2008)
	Involved in cross-boundary collaboration	(Bal and Teo, 2001a, Gassmann and Von Zedtwitz, 2003b, Rezgui, 2007, Precup *et al*., 2006)
Other characteristics	It is not a permanent team	(Bal and Teo, 2001a, Paul *et al*., 2005, Wong and Burton, 2000, Cascio and Shurygailo, 2003, Leenders *et al*., 2003)
	Small team size	(Bal and Teo, 2001a)
	Team member are knowledge workers	(Bal and Teo, 2001a, Kirkman *et al*., 2004)
	Team members may belong to different companies	(Dafoulas and Macaulay, 2002, Leenders *et al*., 2003)

A summary of the definition of virtual team may be taken as: small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks.

Types of Virtual Team:

Generally, we can differentiate various forms of "virtual" work depending on the number of persons involved and the degree of interaction between them. The first is "*telework*" (telecommuting) which is done partially or completely outside of the main company workplace with the aid of information and telecommunication services."*Virtual groups*" exist when several teleworkers are combined and each member reports to the same manager. In contrast, a "*virtual team*" exists when the members of a virtual group interact with each other in order to accomplish common goals. Finally, "*virtual communities*" are larger entities of distributed work in which members participate via the internet, guided by common purposes, roles and norms. In contrast to virtual teams, virtual communities are not implemented within an organizational structure but are usually initiated by some of their members. Examples of virtual communities are Open Source software projects (Hertel *et al*., 2005). Teleworking is viewed as an alternative way to organize work that involves the complete or partial use of ICT to enable workers to get access to their labor activities from different and remote locations (Martinez-Sanchez *et al*., 2006). Telework provides cost savings to employees by eliminating time-consuming commutes to central offices and offers employees more flexibility to co-ordinate their work and family responsibilities (Johnson *et al*., 2001). Cascio and Shurygailo (2003) have clarified the difference form of virtual team by classifying it with respect to two primary variables namely, the number of location (one or more) and the number of managers (one or more) Table 2 illustrates this graphically. Therefore there are four categories of teams:

1. Teleworkers: A single manager of a team at one location
2. Remote team: A single manager of a team distributed across multiple location
3. Matrixed teleworkers: Multiple manager of a team at one location
4. Matrixed remote teams: Multiple managers across multiple locations

Table 2: Forms of Virtual Teams (Cascio and Shurygailo, 2003)

		Managers	
		One	Multiple
Locations	One	Teleworkers	Matrixed Teleworkers
	Multiple	Remote Team	Matrixed Remote Teams

Computer mediated collaborations (CMC) is also used to encompass asynchronous interactions through a collaborative workspace, as well as e-mail, instant messaging, and synchronous interactions using a system that incorporates desktop videoconferencing, shared workspace, chat and other features (Rice *et al*., 2007). On the other hand extended enterprise concept in parallel with the concurrent enterprising looks for how to add value to the product by incorporating to it knowledge and expertise coming from all participants on the product value chain (Sorli *et al*., 2006). Collaborative networked organizations (CNOs) are complex entities whose proper understanding, design, implementation, and management require the integration of different modeling perspectives (Camarinha-Matos and Afsarmanesh, 2007).

Examples of Uses of Virtual Team:

Working in today's business world is like working in a world where the sun never sets. Rezgui (2007) investigates the effectiveness of virtual teams, and any other suitable form of virtual collaboration, in the construction sector and explores the factors that influence their successful adoption. May and Carter (2001) in their case study of virtual team working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits are better quality, reduced costs and a reduction in the time-to-market (between 20% to 50%)for a new product vehicle. New product development (NPD) requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez *et al*., 2006, McDonough *et al*., 2001, Ozer, 2000) and NPD teams are necessary in almost all businesses (Leenders *et al*., 2003). In addition, the pressure of globalization competition companies face increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements(Cummings and Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough *et al*., 2001). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage (Taifi, 2007).

On the other hand, virtuality have been presented as one solution for small and medium enterprises (SMEs) aiming to increase their competitiveness (Pihkala *et al*., 1999). The SMEs are one of the sectors that have a strong potential to benefit from advances in ICTs and the adaptation of new business modes of operation. The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtually invention (Miles *et al*., 2000).

Benefits and Draw Back of Virtual Team:

During the last decade, words such as "virtual", "virtualization", "virtualized" have been very often advocated by scholars and practitioners in the discussion of social and economic issues(Vaccaro *et al*., 2008) but the advantages and pitfalls of virtual team is concealed. The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. Anderson *et al*. (2007) suggest that the effective use of communication, especially during the early stages of the team's development, plays an equally important role in gaining and maintaining trust. Virtual R&D teams which members do not work at the same time or place (Stoker *et al*., 2001) often face tight schedules and a need to start quickly and perform instantly (Munkvold and Zigurs, 2007). Virtual team may allow people to collaborate more productivity at a distance, but the tripe to coffee corner or across the hallway to a trusted colleague is still the most reliable and effective way to review and revise a new idea (Gassmann and Von Zedtwitz, 2003a). As a drawback, virtual teams are particularly vulnerable to mistrust, communication break downs, conflicts, and power struggles (Rosen *et al*., 2007). On the other hand, virtual teams reduce time-to-market (May and Carter, 2001). Lead time or time to market has been generally admitted to be one of the most important keys for success in manufacturing companies (Sorli *et al*., 2006). Table 3 summarizes some of the main advantages and Table 4 some of the main disadvantages associated with virtual teaming. We are in a transient phase that is pushing out beyond the envelope of team fundamentals into a space where we begin to lose track of reality (Qureshi and Vogel, 2001). Clearly the rise of network technologies has made the use of virtual teams feasible (Beranek and Martz, 2005). Finally organizational and cultural barriers are another serious impediment to the effectiveness of virtual teams. Many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa and Leidner, 1999).

Forming and performing in virtual teams is useful for projects that require cross-functional or cross boundary skilled inputs and the key to their value creation is to have a defined strategy in place to overcome the issues highlighted, especially the time zones and cultural issues. While communication could be seen as a traditional team issue, the problem is magnified by distance, cultural diversity and language or accent

Table 3: some of the main advantages associated with virtual teaming

Advantages	Reference
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli *et al*., 2004))	(McDonough *et al*., 2001, Rice *et al*., 2007, Bergiel *et al*., 2008, Cascio, 2000, Fuller *et al*., 2006b, Kankanhalli *et al*., 2006, Prasad and Akhilesh, 2002, Olson-Buchanan *et al*., 2007, Boudreau *et al*., 1998, Biuk-Aghai, 2003, Liu and Liu, 2007, Lipnack and Stamps, 2000)
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005)]	(Lipnack and Stamps, 2000, May and Carter, 2001, Sorli *et al*., 2006, Kankanhalli *et al*., 2006, Chen, 2008, Shachaf, 2008, Kusar *et al*., 2004, Ge and Hu, 2008, Mulebeke and Zheng, 2006, Guniš *et al*., 2007, Prasad and Akhilesh, 2002, Zhang *et al*., 2004, Sridhar *et al*., 2007)
Able to digitally or electronically unite experts in highly specialized fields working at great distances from each other	(Rosen *et al*., 2007)
More effective R&D continuation decisions	(Cummings and Teng, 2003, Schmidt *et al*., 2001)
Most effective and rapid in making decisions	(Hossain and Wigand, 2004, Paul *et al*., 2004b, Bal and Gundry, 1999)
Able to tap selectively into center of excellence, using the best talent regardless of location	(Criscuolo, 2005, Cascio, 2000, Samarah *et al*., 2007, Fuller *et al*., 2006b, Furst *et al*., 2004, Badrinarayanan and Arnett, 2008, Prasad and Akhilesh, 2002, Boudreau *et al*., 1998, Boutellier *et al*., 1998)
Greater degree of freedom to individuals involved with the development project	(Ojasalo, 2008, Badrinarayanan and Arnett, 2008, Prasad and Akhilesh, 2002)
Greater productivity, shorter development times	(McDonough *et al*., 2001, Mulebeke and Zheng, 2006)
Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources.	(Martins *et al*., 2004, Rice *et al*., 2007, Chen *et al*., 2008b)
Useful for projects that require cross-functional or cross boundary skilled inputs	(Lee-Kelley and Sankey, 2008)
On time implementation of the tasks assigned, Less resistant to change	(Precup *et al*., 2006)
Integrating talent in newly industrialized Facilitating transnational innovation processes	(Gassmann and Von Zedtwitz, 2003b, Prasad and Akhilesh, 2002)
Higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another)	(Kratzer *et al*., 2005, Cascio, 2000, Gaudes *et al*., 2007)
Evolving organizations from production-oriented to service /information-oriented, Faster response times to tasks, Providing flexible hours for the employees, More sense of responsibility is more developed	(Johnson *et al*., 2001, Precup *et al*., 2006)
Provide organizations with unprecedented level of flexibility and responsiveness	(Powell *et al*., 2004, Hunsaker and Hunsaker, 2008, Chen, 2008, Guniš *et al*., 2007, Prasad and Akhilesh, 2002, Pihkala *et al*., 1999, Piccoli et al., 2004, Liu and Liu, 2007)
Perform their work without concern of space or time constraints	(Lurey and Raisinghani, 2001)
Self-assessed performance and high performance.	(Chudoba *et al*., 2005, Poehler and Schumacher, 2007)
Optimize the contributions of individual members toward the completion of business tasks and organizational goal	(Samarah *et al*., 2007)
Reduce the pollution, Creates and disperses improved business processes across organizations	(Johnson *et al*., 2001)
The ratio of virtual R&D member publications exceeded from co-located publications	(Ahuja *et al*., 2003)
The extent of informal exchange of information is minimal (virtual teams tend to be more task oriented and exchange less socio emotional information	(Pawar and Sharifi, 1997, Schmidt *et al*., 2001)
Can manage the development and commercialization tasks quite well	(Chesbrough and Teece, 2002)
Respond quickly to changing business environments	(Bergiel *et al*., 2008, Mulebeke and Zheng, 2006)
Improve communication and coordination, and encourage the mutual sharing of inter-organizational resources and competencies	(Chen *et al*., 2008a)
Team communications and work reports are available online to facilitate swift responses to the demands of a global market. Employees can be assigned to multiple, concurrent teams; dynamic team membership allows people to move from one project to another. Employees can more easily accommodate both personal and professional lives	(Cascio, 2000)
Cultivating and managing creativity	(Leenders *et al*., 2003, Prasad and Akhilesh, 2002, Atuahene-Gima, 2003, Badrinarayanan and Arnett, 2008)
Sharing knowledge, experiences; Facilitate knowledge capture	(Rosen *et al*., 2007, Zakaria*et al*., 2004, Furst *et al*., 2004, Merali and Davies, 2001, Sridhar *et al*., 2007, Lipnack and Stamps, 2000)

Table 3: Continue

Improve the detail and precision of design activities	(Vaccaro *et al*., 2008)
Provide a vehicle for global collaboration and coordination of R&D-related activities	(Paul *et al*., 2005)
Allow organizations to access the most qualified individuals for a particular job regardless of their location.	(Hunsaker and Hunsaker, 2008)
Enable organizations to respond faster to increased competition	(Hunsaker and Hunsaker, 2008, Pauleen, 2003)
Better team outcomes (quality, productivity, and satisfaction)	(Gaudes *et al*., 2007, Ortiz de Guinea *et al*., 2005, Piccoli *et al*., 2004)
Higher team effectiveness and efficiency	(May and Carter, 2001, Shachaf and Hara, 2005)
Reduce training expenses, Faster Learning	(Pena-Mora *et al*., 2000, Atuahene-Gima, 2003, Badrinarayanan and Arnett, 2008)
Greater client satisfaction	(Jain and Sobek, 2006)

Table 4: some of the main disadvantages associated with virtual teaming

Disadvantages	references
Sometimes requires complex technological applications	(Bergiel *et al*., 2008, Badrinarayanan and Arnett, 2008)
Face-to-Face collaboration (FFC) appears to be better developing a conceptual understanding of a problem (lack of physical interaction)	(Cascio, 2000, Hossain and Wigand, 2004, Kankanhalli *et al*., 2006, Rice *et al*., 2007)
Decrease monitoring and control of activities	(Pawar and Sharifi, 1997)
Everything to be reinforced in a much more structured, formal process	(Lurey and Raisinghani, 2001).
Vulnerable to mistrust, communication break downs, conflicts, and power struggles	(Rosen *et al*., 2007, Cascio, 2000, Kirkman *et al*., 2002, Taifi, 2007, Baskerville and Nandhakumar, 2007)
Challenges of project management are more related to the distance between team members than to their cultural or language differences	(Wong and Burton, 2000, Martinez-Sanchez *et al*., 2006, Badrinarayanan and Arnett, 2008, Jacobsa *et al*., 2005).
Challenges of determining the appropriate task technology fit	(Qureshi and Vogel, 2001, Ocker and Fjermestad, 2008, Griffith et al., 2003, Badrinarayanan and Arnett, 2008, Bell and Kozlowski, 2002, Pawar and Sharifi, 2000)
Challenges of managing conflict	(Hinds and Mortensen, 2005, Ocker and Fjermestad, 2008, Kayworth and Leidner, 2002, Piccoli *et al*., 2004, Wong and Burton, 2000, Ramayah *et al*., 2003)
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	(Bell and Kozlowski, 2002, Griffith *et al*., 2003, Shachaf, 2005, Jacobsa *et al*., 2005, Paul *et al*., 2005 , Poehler and Schumacher, 2007, Kankanhalli *et al*., 2006, Badrinarayanan and Arnett, 2008, Munkvold and Zigurs, 2007, Boutellier *et al*., 1998)
Will create challenges and obstacles like technophobia (employees who are uncomfortable with computer and other telecommunications technologies)	(Johnson *et al*., 2001)
Variety of practices (cultural and work process diversity) and employee mobility negatively impacted performance in virtual teams.	(Chudoba *et al*., 2005)
Team members need special training and encouragement	(Ryssen and Godar, 2000)

difficulties. For migration or similar large-scale projects, personal project management competency, appropriate use of technology and networking ability, willingness for self-management, cultural and interpersonal awareness is fundamentals of a successful virtual team (Lee-Kelley and Sankey, 2008).Thomas and Bostrom (2005) found that a technology facilitator role can be critically important to virtual team success.

Virtual and Traditional Teams:

Unlike a traditional team, a virtual team works across space, time and organizational boundaries with links strengthened by webs of communication technologies. However, many of the best practices for traditional teams are similar to those for virtual teams (Bergiel *et al*., 2008). Virtual teams are significantly different from traditional teams. In the proverbial traditional team, the members work next to one another, while in virtual teams they work in different locations. In traditional teams the coordination of tasks is straightforward and performed by the members of the team together; in virtual teams, in contrast, tasks must be much more highly structured. Also, virtual teams rely on electronic communication, as opposed to face-to-face communication in traditional teams. *Table 5* summarizes these distinctions (Kratzer *et al*., 2005). In particular, reliance on computer-mediated communication makes virtual teams unique from traditional ones (Munkvold and Zigurs, 2007).

Kratzer *et al*. (2005) research shows that traditional R&D teams have become rare. The processes used by successful virtual teams will be different from those used in face-to-face collaborations (FFCs) (Rice *et al*., 2007). In an innovation network resembling a "traditional" organization, the innovation process is more

Table 5: Virtual and traditional teams are usually viewed as opposites

Fully Traditional Team	Fully Virtual Team
Team members all co-located.	Team members all in different locations.
Team members communicate face-to-face (i.e., synchronous and personal)	Team members communicate through asynchronous means.
Team members coordinate team task together, in mutual adjustment.	The team task is so highly structured that coordination by team members is rarely necessary.

restricted by location and time. In other words, the innovation process mostly takes place within the framework of physical offices and working hours. In virtual organizations, individuals' work is not restricted by time and place, and communication is strongly facilitated by IT. Such a product development environment allows a greater degree of freedom to individuals involved with the development project (Ojasalo, 2008). Hence multinational companies (MNC) are more likely to become tightly integrated into global R&D network than smaller unit (Boehe, 2007). Distributed teams can carry out critical tasks with appropriate decision support technologies (Chen *et al*., 2007).

Yip and Dempster, (2005) in their study realized that perhaps the most important lesson is that the internet helps companies to be both global and local at the same time. It is possible to derive the virtual teams substitute with internet. The internet can facilitate the collaboration of different people who are involved in product development, increase the speed and the quality of new product testing and validation and improve the effectiveness and the efficiency of product development and launch (Martinez-Sanchez *et al*., 2006). Rice *et al*., (2007) found that the adoption of formal procedures and structured processes significantly increased the effectiveness of virtual teams. (Arranz and Arroyabe, 2008) point out that geographical dimension is not a variable that impacts substantially on the typology and objectives of R&D cooperation, in contrast with the results highlighted in the literature review that they have done. Virtual teams have more effective R&D continuation decisions than face-to-face teams because virtual team has asynchronous communication and it allows for more time for digestion and reduces the pressure of group conformity (Cummings and Teng, 2003).

Physical vs. Virtual:

(Pawar and Sharifi, 1997) study of virtual versus collocated team success and classified physical teams versus virtual teams in six categories. Table 6 summarizes these differences.

Table 6: classifying physical teams versus virtual teams

Activity	Physical teams nature	Virtual teams nature
Nature of interaction	opportunity to share work and non-work related information	the extent of informal exchange of information is minimal
Utilization of resources	Increases the opportunity for allocation and sharing of resources	each collaborating body will have to have access to similar technical and non-technical infrastructure
Control and accountability (over and within the project):	the project manager provides the context for ongoing monitoring of activities and events and thus enhances their ability to respond to requirements.	The collaborating bodies were accountable to the task leaders and the project coordinator who had limited authority to enforce any penalties for failure to achieve their tasks
Working environment	they encountered constraints accessing information and interacting with others outside the collocated team within the company	sometimes not able to share ideas or dilemmas with other partners.
Cultural and educational background	members of the team are likely to have similar and complementary cultural and educational background	the team members varied in their education, culture, language, time orientation and expertise
Technological compatibility:	situated and operating within a single organization, faces minimal incompatibility of the technological systems	compatibility between different systems in collaborating organizations ought to be negotiated at the outset

Most likely, virtual teams will not totally replace conventional teams. Although virtual teams are and will continue to be an important and necessary type of work arrangement, they are not appropriate for all circumstances (Nemiro, 2002). Lurey and Raisinghani (2001) base on virtual teams survey in 12 separate virtual teams from eight different sponsor companies in the high technology found that, organizations choosing to implement virtual teams should focus much of their efforts in the same direction they would if they were implementing traditional, co-located teams. Hossain and Wigand (2004) conclude that ICT-enabled virtual collaboration would be effective with the existence of face-to-face communication support and would lead to higher levels of satisfaction in collaboration. Diversity in national background and culture is common in transnational and virtual teams (Staples and Zhao, 2006). Past research has found that interaction in computer-mediated communication environments is more impersonal, more task oriented, more businesslike, and less

friendly than in face-to-face settings (Schmidt *et al*., 2001). Akgün *et al* (2008) found that the use of ICT had a positive influence on the knowledge base team's performance.

Challenges for Virtual Team:

Virtual teams face particular challenges involving trust (Malhotra *et al*., 2007, Bal and Teo, 2001b, Paul *et al*., 2004b) which is a key element to build successful interactions and to overcome selfish interests, effective communication (Beranek and Martz, 2005, Dustdar, 2004) that is even more critical for success in the virtual setting (Shachaf and Hara, 2005), deadlines (Jarvenpaa and Leidner, 1999), and team cohesiveness (Dineen, 2005). While there are great advantages that come with the adoption of the virtual teams, new challenges rise with them (Precup *et al*., 2006). Cascio (2000) declared that there are five main disadvantages to a virtual team: lack of physical interaction, loss of face-to-face synergies, lack of trust, greater concern with predictability and reliability, and lack of social interaction. In building a virtual team, all of these issues must be at least implicitly addressed in order to have an effective virtual team (Hunsaker and Hunsaker, 2008). Virtual teams are challenged because they are virtual; they exist through computer mediated communication technology rather than face-to-face interactions (Gaudes *et al*., 2007, Hardin et al., 2007). Sometimes they report to different supervisors and they function as empowered professionals who are expected to use their initiative and resources to contribute to accomplishment of the team goal (Hunsaker and Hunsaker, 2008). Fewer opportunities for informal work- and non-work-related conversations may form challenges to virtual team (Furst *et al.,* 2004). Furthermore, virtual teams member are expected to become interdependent, successfully negotiate cultural differences (Dafoulas and Macaulay, 2002, Dekker *et al*., 2008), and accomplish their tasks through computer-mediated technology (Hunsaker and Hunsaker, 2008). The process to motivate team members may differ depending on their orientation (Paul *et al*., 2004a).

What Is Needed for Effective Virtual Team:

A review of the literature shows the factors that impact on the effectiveness of virtual teams are still ambiguous. Many of the acknowledged challenges of effective virtual team working, focus on ensuring good communication among all members of the distributed team (Anderson *et al*., 2007). For example, Jarvenpaa and Leidner (1999) found that regular and timely communication feedback was key to building trust and commitment in distributed teams. Lin *et al*.(2008) study indicates that social dimensional factors need to be considered early on in the virtual team creation process and are critical to the effectiveness of the team. Communication is a tool that directly influences the social dimensions of the team and in addition the performance of the team has a positive impact on satisfaction with the virtual team.

For teams moving from co-location to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams (Kirkman *et al*., 2002). Despite weak ties between virtual team members, ensuring lateral communication maybe adequate for effective virtual team performance. In terms of implementation, lateral communication in both virtual context and composition teams can be increased by reducing the hierarchical structure of the team (i.e. a flatter reporting structure and/or decentralization) and the use of enabling computer-mediated communication tools (Wong and Burton, 2000).

Malhotra and Majchrzak's (2004) study of 54 effective virtual teams found that creating a state of shared understanding about goals and objectives, task requirements and interdependencies, roles and responsibilities, and member expertise had a positive effect on output quality. As criteria, effectiveness ratings were Hertel *et al*. (2005) collected from the team managers both at the individual and at the team level. The results of the field study showed good reliability of the task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara (2005)suggests four dimensions of effective virtual team leadership:

1. Communication (the leader provides continuous feedback, engages in regular and prompt communication, and clarifies tasks);
2. Understanding (the leader is sensitive to schedules of members, appreciates their opinions and suggestions, cares about member's problems, gets to know them, and expresses a personal interest in them);
3. Role clarity (the leader clearly defines responsibilities of all members, exercises authority, and mentors virtual team members); and
4. Leadership attitude (the leader is assertive yet not too "bossy," caring, relates to members at their own levels, and maintains a consistent attitude over the life of the project).

Bal and Teo (2001c) similar to their study in (1999) by observation and interview identified 12 elements for effective virtual team working. It is illustrated in Figure 1. The Bal and Gundry (2001c, 1999) model is used as the basic framework for the discussions on topic.

Virtual Team Working: Technology Point of View:

Selection:

Simple transmission of information from point A to point B is not enough; the virtual environment presents significant challenges to effective communication (Walvoord *et al*., 2008). Being equipped with even the most advanced technologies is not adequate to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be present for a team to succeed in the virtual world (Lurey and Raisinghani, 2001). Information richness seemed to be the most important criterion for technology selection; and the greatest impediment to the effectiveness of virtual teams was the implementation of technology (Mikkola *et al*., 2005). Virtual teams are technology-mediated groups of people from different discipline that work on common tasks (Dekker *et al*., 2008) so the way the technology is implemented seems to make virtual teams outcome more or less likely (Anderson *et al*., 2007). Table 7 matrix assist the virtual team facilitator choose the appropriate technology based upon the purpose of the meeting.

Table 7: Tools for virtual teams (Adopted from Thissen et al. (2007))

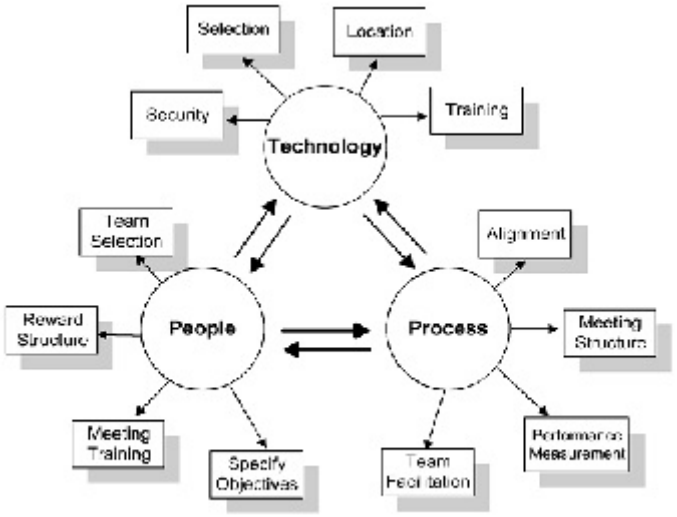
Tool	Examples	Uses and Advantages	Immediacy	Sensory Modes
Instant Messaging and Chat	• Yahoo Messenger • MSN Messenger • AOL Instant Messenger • Skype	• Instant interaction • Less intrusive than a phone call • View who is available • Low cost • Low setup effort	• Synchronous or asynchronous	• Visual • Text and limited graphics
Groupware / Shared Services	• Lotus Notes • Microsoft Exchange • Novell Groupwise	• Calendars • Contact Lists • Arrange meetings • Cost and setup effort vary	• Asynchronous	• Visual
Remote Access and Control	• NetMeeting • WebEx • Remote Desktop • pcAnywhere	• User controls a PC without being onsite • Cost varies • Setup varies	• Synchronous	• Visual • Audio • Tactile
Web Conferencing	• NetMeeting • WebEx • Meeting Space • GoToMeeting	• Live audio • Dynamic video • Whiteboard • Application sharing • Moderate cost and setup effort	• Synchronous	• Visual • Unlimited graphics • Optional audio
File Transfer	• File Transfer Protocol (FTP) • Collaborative Websites • Intranets	• Share files of any type • Cost varies • Moderate setup effort	• Asynchronous	• Varies with file content
Email	• Numerous vendors and • free applications	• Send messages or files • Cost and setup effort vary	• Asynchronous	• Visual • Audio in attached files
Telephone	• "Plain Old Telephone Service" (POTS) • Voice Over Internet Protocol (VOIP)	• Direct calls • Conference calls • Cost varies • Low setup effort	• Synchronous • Asynchronous for voice mail	• Audio

Location:

Virtual team allow organizations to access the most qualified individuals for a particular job regardless of their location and provide greater flexibility to individuals working from home or on the road (Bell and Kozlowski, 2002). Table 8 illustrates the relationship between tool, time and space in virtual teams.

Training:

Suggestions for the training of remote managers and virtual team development can be found in the literature (Hertel *et al*., 2005). The results of Anderson *et al*. (2007) systematic lab study confirm many of the observations include explicit preparation and training for virtual teams as a way of working collaboratively. Fuller *et al*., (2006b) results indicate that in the case of computer collective efficacy, computer training related to more advanced skills sets may be useful in building virtual team efficacy. The Hertel *et al*. (2005) suggested that the training led to increased cohesiveness and team satisfaction.



Source: Bal and Gundry (1999)

Fig. 1: Model for effective virtual team working

Table 8: Time /Space matrix (Adapted from Bouchard and Cassivi (2004))

	Same space	Different space
Same time Synchronous	Face-to-face meeting, Brainstorming, Vote, PC and projector Electronic white board, GDSS, Chat	Chat, Tele-conference, Video-conference, Liaison satellite, Audio-conference, Shared white board, Shared application
Different time Asynchronous	Team room, Document management system, Discussion forum, E-mail, Workflow, Project management	E-mail, Workflow, Document sharing, Discussion forum, Group agenda Cooperative hypertext and organizational memory, Version control Meeting scheduler

Security:

Virtual team working involve exchange and manipulation of sensitive information and data through the Internet, therefore security is always an important issue of concern (Bal and Teo, 2001c). Team leaders should identify the special technological and security level needs of the virtual team and their team members (Hunsaker and Hunsaker, 2008).

Virtual Team Working: People Point of View:

Team selection: Team selection is a key factor which differentiates successful teams from unsuccessful ones. Virtual teams can be designed to include the people most suited for a particular project (Bell and Kozlowski, 2002). Virtual team leaders rather than need to make sure the project is clearly defined, outcome priorities are established, and that a supportive team climate, need to select members with necessary skills (Hunsaker and Hunsaker, 2008). Selection of virtual team members is particularly difficult because of the geographical and organizational separation involved (Bal and Gundry, 1999).

Reward Structure:

The development of a fair and motivating reward system is another important issue at the beginning of virtual teamwork (Bal and Teo, 2001b, Hertel *et al*., 2005). Virtual team performance must be recognized and rewarded (Bal and Gundry, 1999). (Lurey and Raisinghani (2001) in a survey in an effort to determine the factors that contribute to the success of a virtual team, found that reward systems ranked strongly among the external support mechanisms for virtual teams.

Meeting Training:

Comparing teams with little and extensive training, Bal and Gundry (1999) observed a significant drop in performance as both teams went live using the system. However, the latter then improved its performance at a faster rate than the former. Training is a key aspect that cannot be neglected in team building. Virtual team members require some different types of training to ordinary teams. The training includes self-managing skills, communication and meeting training, project management skills, technology training, etc. (Bal and Teo, 2001c).

Specify Objective:

While direct leadership strategies are possible in conventional teams, members of virtual teams might be managed more effectively by empowerment and by delegating managerial functions to the members (Hertel *et al*., 2005). Such an approach changes the role of a team manager from traditional controlling into more coaching and moderating functions (Kayworth and Leidner, 2002). Virtual team leaders should identify commonalities among members early on, while focusing the team on achieving key performance objectives and providing a clear context for recognizing team success.

Virtual Team Working: Process Point of View:

Alignment:

The company's processes need to be re-aligned with the capabilities of virtual teams as opposed to face to face teams. This involves an understanding of the virtual team processes and the existing processes (Bal and Gundry, 1999). However, the key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing process (Rosen *et al*., 2007).

Meeting Structure:

Proximity enables team members to engage in informal work (Furst *et al*., 2004). Virtual team members are more likely to treat one another formally, and less likely to reciprocate requests from one another (Wong and Burton, 2000). Shin (2005) argued that lack of physical interactions and informal relationships decrease the cohesiveness of virtual teams. Formal practices and routines designed to formally structure the task, was reported to lead to higher quality output of virtual team (Massey *et al*., 2003). The physical absence of a formal leader exacerbates lack of extrinsic motivation (Kayworth and Leidner, 2002). In virtual teams that rarely meet face-to-face, team leaders often have no choice but to implement a formal team structure. Synchronous written documents helped virtual teams overcome challenges associated with spoken language, and this enabled teams to overcome challenges associated with asynchronous and lean written communication (Shachaf, 2008).

Performance Measurement:

Work on the performance of virtual teams by Kirkman and Rosen, *et al*. (2004) demonstrates a positive correlation between empowerment and virtual team performance. High-performance teams are distinguished by passionate dedication to goals, identification and emotional bonding among team members, and a balance between unity and respect for individual differences.

Team Facilitation:

Virtual team members must have clear roles and accountabilities. Lack of visibility may cause virtual team members to feel less accountable for results, therefore explicit facilitation of teamwork takes on heightened importance for virtual teams. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability (Massey *et al*., 2003).

Conclusion:

Strong business and social pressures are driving the adoption of virtual team working. This paper with a comprehensive review of literature and related resources covering the topic along with Bal and Teo (2001c), find that success in implementing virtual team working is more about processes and people than about technology. Virtual teams offer many benefits to organizations striving to handle a more demanding work environment, but also present many challenges and potential pitfalls. With comparing Table 3, with Table 4 it is clearly obvious that advantages of utilize virtual teams are far from its disadvantages so dealing with it can bring new findings. Virtual teams are a new and exciting work form with many fascinating opportunities. Due to these opportunities, virtual teamwork becomes increasingly popular in organizations.

This paper has identified and extended 12 key factors that need to be considered, and describes a methodology focused on supporting virtual team working, with a new approach that has not been specifically addressed in the existing literature. These findings provide an important step in studying how virtual team efficacy is formed and what its consequences are in the context of virtual teams. It is apparent from the literature review that significant differences are between virtual teams and co-located teams hence manager of virtual teams should not ignore these differences at their own peril. Suggestions for the training of remote managers and virtual team development can be found in the literature. Manager of virtual team should

overcome the managing conflict, cultural and functional diversity in virtual teams and mistrust among the team members

Future research would now seem to be essential for developing a comprehensive study, combining literature survey with case study in different size of companies (e.g. multinational companies and small and medium enterprises) and various types of activities (e.g. research and development and new product development). Such a study would provide an assessment what patterns, practices, or types of activities must virtual teams carry out to achieve effectiveness in the competitive environment?, How such teams should be managed? What types of process structure and technology support should be provided for facilitating such teams?, What different methods of virtual team are used today and how effective are they?, What benefits and problems arise as a consequence of the creation of virtual team? and How to make the transition from a more traditional team structure to the more distributed team structure?. These questions and many other practical questions wait for future empirical investigation.

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Applied Mechanics and Materials Vols. 110-116 (2012) pp 258-266

doi:10.4028/www.scientific.net/AMM.110-116.258

Models for Component Commonality in Multistage Production

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Keywords: component commonality; Mathematical model

Abstract. Use of common parts for different products (commonality) is important methods for managing product variety and preserving competitiveness in the age of mass customization and supply chain competition. In literature, the advantages of inclusion of common components in a product family are well established. Unfortunately, most of the works have been conducted via simulation or conceptual thinking. The mathematical models in the premises are not adequate for production, planning and control in multistage production. This paper focuses on the advancement of venerable manufacturing resources planning models by incorporating the part commonality concept in a multiproduct, multi-period and multistage manufacturing system under a deterministic situation. The models are validated with established MRPII models. The material requirement schedule for the basic MRP II and proposed models are compared. It is really a good matching shown between the two schedules. The later bearing additional information of the location where to be available the parts in a time frame. The effects of commonality on cost, capacity and requirement schedule are discussed based on the outcomes of the mathematical models executed with the available live data.

Introduction

The underlying ideas for commonality are not really new. As early as 1914, an automotive engineer demanded the standardization of automobile subassemblies, such as axles, wheels and fuel feeding mechanisms to facilitate a mix-and-matching of components and to reduce costs [1]. Commonality is the use of identical components in multiple/group of products in a product family. In manufacturing, component commonality refers to the use the same components for two or more products in their final assemblies. Commonality substantially lowers the costs of proliferated product lines, mitigate the effects of product proliferation on product and process complexity [2]. It reduces the cost of safety stock, decreases the setup time, increases productivity, and improves flexibility [3]. The required number of order (or setups) [4-5] pooling effect and lead time uncertainty are also condensed when part commonality is applied. Furthermore, it improves the economy of scale, simplify planning, scheduling and control, streamlines and speeds up product development process [6]. The details about the commonality, its measurements and models are narrated in Wazed et al.[7]. The commonality occurs in its own way in the system or can be planned for its preferred happening as well.

Nowadays, manufacturing companies need to satisfy a wide range of customer desires while maintaining manufacturing costs as low as possible, and many companies are faced with the challenge of providing as much variety as possible for the market with as little variety as possible between the products. Hence, instead of designing new products one at a time, many companies are now designing families. Hence, the component commonality has wide scope to penetrate in the manufacturing and thereby might allow cost-effective development of sufficient variety of products to meet customers' diverse demands. However, too much commonality within a product family can have major drawbacks. Consequently, there is a need of tradeoff between system performance and commonality within any product family.

MRP II is the widely used tool in the manufacturing. Even though the value of the MRP II that can bring to companies is clear, and a few will refuse its potential, numerous organizations have failed or are failing to apply effectively the advantages that this system can give. The same material requirement planning (MRP) logic is used in MRPII, enterprise resources planning (ERP) and extended ERP (ERP II) in their production-planning modules [8], thus their inability to cope and respond to uncertainty is still prevailing and the planned order release (POR) schedules are indifferent to those generated from an MRP system [9-10]. Enns [8] stated that MRP, MRPII or ERP is the ideal system within a batch-manufacturing environment. If resource loading and lead times are identical to those planned in the MRP systems, then the functions of such systems in planning and control will be ideal [11]. However, the production planning systems (viz. MRP, MRP II, ERP and ERP II) were designed and developed to operate within a stable and predictable batch manufacturing environment. Hence they are not capable of tackling uncertainty [12]. For details on the factors and sources of various uncertainties, the authors humbly like to refer the readers to Wazed et al. [13].

In earlier studies [2-4, 6-7, 14-20], the benefits of component commonality in the manufacturing systems associated with a decrease in inventory, lowers the costs of proliferated product lines, mitigate the effects of product proliferation on product and process complexity, reduce the cost of safety stock, decrease the set-up time, increase productivity, improve flexibility, permit greater operating economies of scale, facilitates quality improvement, enhance supplier relationship and reduce product development time, risk-pooling and lead time uncertainty reduction, simplify planning, schedule and control, streamline and speed up product development process, lowers the setup and holding costs, offer high variety while retaining low variety in operations, lower the manufacturing cost and design savings are obtained. However, the commonality issue is completely ignored in the existing manufacturing resource planning models. Furthermore, the analytical research on multistage manufacturing is very few in the present pool of knowledge. Hence, this article will advance the existing MRP II models by integrating component commonality concept.

Component Commonality Model

The component commonality models are developed from venerable MRP II models. This model is a useful starting point for further modeling. MRP II was inspired by shortcomings in MRP. The data requirements are nearly the same as for MRP.

Using classic MRP II software, problem MRP II would not be solved directly. Instead, problem MRP would be solved and then the capacity constraint for the MRP II model would be checked. In other words, the result of solving problem MRP provides values for the decision variables. Once these values are known, they become data for subsequent processing. Direct solution of the optimization model is a much better idea. In practice, the problem is bigger and harder to solve than the simple MRP II models that have presented. However, MRP II provides us with a good jumping off point for more sophisticated models because it mimics a widely used planning tool. We can and will embed these constraints in a model that captures costs and constraints that are important to the manufacturing organization or the supply chain. Especially the dashing thought of component commonality is to be incorporated.

Multistage Production Models in Deterministic Conditions

In this section we introduce a class of models that is based on the simplest assumption: demand, lead time, quality and breakdowns are deterministic and stationary. We concentrate primarily on the case where the information of the factors is constant and not anticipated to change. Although the assumption of deterministic and stationary factors seems quite restrictive, models requiring that assumption are still important for the following reasons. First, many results are quite robust with respect to the model parameters, such as the demand rate and costs. Second, the results obtained from these simple models are often good starting solutions for more complex models.

We consider an K-stage assembly/manufacturing line that produces $ENDP$ products as illustrated in Figure 1 (a- end product, b- component and c- manufacturing/assembly line). The production/assembly process of a product starts at stage 1. When a component moves along the line,

component (module) is added onto it at some of the K stages. In general each production line is specified for a product if sharing of resources is not permitted. The resources are identified by the product, P it producing and stage, K of the system. Component C_{Pkit} is assembled to the product $i\,(i=1,..,N)$ in period $t\,(t=1,..,T)$ at resource $WC(P,K)$ *for* $P=1,..,ENDP$ *and* $k=1,..,K$.

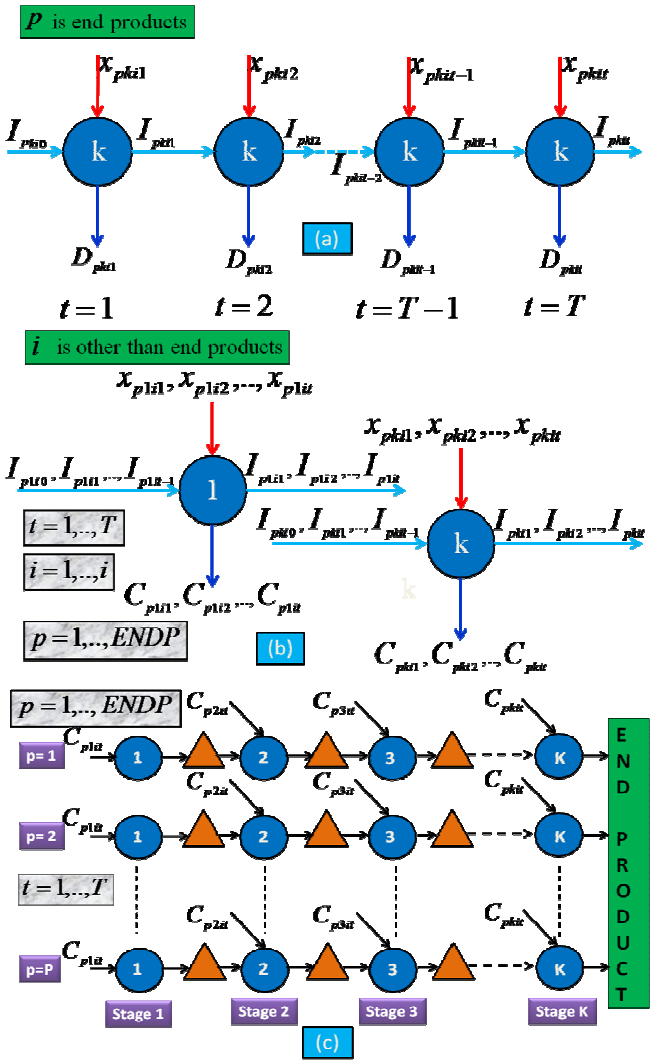

Figure 1. A multistage production system

We assume that components are purchased from external suppliers with deterministic replenishment lead-times. The lead-time is $LT(p,k,i)$ for component/module i at $WC(p,k)$. Based on the illustration, the demand and component requirement constraints can be written as

$$I_{pkit-1}+\sum_{\tau=1}^{t-LT(p,k,i)} x_{pki\tau}-IP_{pkit}\geq D(p,k,i,t)$$

$$p=1,..,ENDP;\quad k=1,..,K;\quad i=p;t=1,..,T$$

$$I_{pkit-1}+\sum_{\tau=1}^{t-LT(p,k,i)} x_{pki\tau}-I_{pkit}\geq \sum_{\tau=1}^{t}\sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau}+IP_{pkit}\right)$$

$$p=1,..,ENDP;\quad i=1,..,N\setminus ENDP;\quad k=1,..,K;\quad t=1,..,T$$

$$C_{pkit}\geq \sum_{\tau=1}^{t}\sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau}+IP_{pkit}\right)$$

$$p=1,..,ENDP;\quad i=1,..,N\setminus ENDP;\quad k=1,..,K;\quad t=1,..,T$$

The complete model for multistage system under ideal conditions is shown in Figure 2. Component purchasing cost, variable production cost and inventory costs for products and components and setup cost of the machines are taken into consideration.

Objective function

$$Minimize \quad z = \sum_{WC(P,K)} \sum_{I} \sum_{T} \left(v_i x_{pkit} + q_i I_{pkit}\right) + \sum_{WC(P,K)} \sum_{I} \sum_{T} f_{pk}\left(y_{pkit} - \gamma_{pkit}\right) + \sum_{WC(P,K)} \sum_{T} c_{WC} OT_{pkt}$$

Subject to

$$I_{pkit-1} + \sum_{\tau=1}^{t-LT(p,k,i)} x_{pkit\tau} - I_{pkit} \geq D(p,k,i,t) \quad p = 1,..,ENDP; \quad k = 1,..,K; \quad i = p; t = 1,..,T$$

$$I_{pkit-1} + \sum_{\tau=1}^{t-LT(p,k,i)} x_{pkit\tau} - I_{pkit} \geq \sum_{\tau=1}^{t} \sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau} + I_{pkit}\right)$$

$$p = 1,..,ENDP; \quad i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$C_{pkit} \geq \sum_{\tau=1}^{t} \sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau} + I_{pkit}\right) \quad p = 1,..,ENDP; \quad i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$x_{pkit} - my_{pkit} LS(i) = 0 \quad p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$x_{pkit} \leq My_{pkit} \quad p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$LS(i) \leq My_{pkit} \quad p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

The capacity constraints:

$$\sum_{I} \left\{U(p,k,i) x_{pkit} + ST(p,k,i)\left(y_{pkit} - \gamma_{pkit}\right)\right\} - OT_{Pkt} + UT_{pkt} \leq 1 \quad p = 1,..,ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$OT_{Pkt} \times UT_{pkt} = 0 \quad p = 1,..,ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$y_{pkit-1} + y_{pkit} \geq 2\gamma_{pkit} \quad p = 1,..,ENDP; i = 1,..,N; \quad k = 1,..,K; \quad t = 1,..,T$$

$$\gamma_{pkit} \leq MU(p,k,i) \quad p = 1,..,ENDP; i = 1,..,N; \quad k = 1,..,K; \quad t = 1,..,T$$

$$\sum_{i=1}^{N} \gamma_{pkit} \leq 1 \quad p = 1,..,ENDP; k = 1,..,K; \quad t = 1,..,T$$

Non-negativity constraints:

All variables ≥ 0; $y_{pkit} = \{0,1\}$; $n = Integer$

Figure 2. Model for multistage system under deterministic situations

The third equation of the capacity constraints allow γ to be one for i on machine $WC(p,k)$ only if there is production of p in both periods. The fourth constraints ensure that we only set γ to one for i that are to be routed to machine $WC(p,k)$, which is done mainly to avoid spurious values of γ that can be confusing when reading the solution. The last constraints ensure that at most one product can span the time boundary on a specific resource $WC(p,k)$.

If backlog is allowed, the demand/component requirement constraints and the cost function will be change.

$$Minimize \quad z = \sum_{WC(P,K)} \sum_{I} \sum_{T} \left(v_i x_{pkit} + c_i C_{pkit} + q_i I_{pkit} + b_i B_{pkit}\right) +$$

$$+ \sum_{WC(P,K)} \sum_{I} \sum_{T} f_{pk}\left(y_{pkit} - \gamma_{pkit}\right) + \sum_{WC(P,K)} \sum_{T} c_{WC} OT_{pkt}$$

Demand and component requirement constraints

$$I_{pkit-1} + \sum_{\tau=1}^{t-LT(p,k,i)} x_{pki\tau} - I_{pkit} + B_{pkit} - B_{pkit-1} \geq D(p,k,i,t)$$

$$p = 1,..,ENDP; i = p; \quad k = K; \quad t = 1,..,T$$

$$I_{pkit-1} + \sum_{\tau=1}^{t-LT(p,k,i)} x_{pki\tau} - I_{pkit} + B_{pkit} - B_{pkit-1} \geq$$

$$\sum_{\tau=1}^{t} \sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau} + I_{pkit} + B_{pkit}\right)$$

$$p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$I_{pkit} \times B_{pkit} = 0 \quad p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

When common component is introduced in manufacturing

$$I_{pkct-1} + \sum_{\tau=1}^{t-LT(p,k,c)} x_{pkc\tau} - I_{pkct} + B_{pkct} - B_{pkct-1} \geq$$

$$\sum_{\tau=1}^{t} \left[\sum_{j=1}^{N} R(c,j)\left(x_{pkj\tau} + I_{pkj\tau} + B_{pkj\tau}\right)\right]$$

$$p = 1,..,ENDP; c = 1,..,C; \quad k = 1,..,K; \quad t = 1,..,T$$

$$I_{pkit-1} + \sum_{\tau=1}^{t-LT(p,k,i)} x_{pki\tau} - I_{ikt} + B_{pkit} - B_{pkit-1} \geq$$

$$\sum_{\tau=1}^{t-LT(i,k)} \left[\sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau} + I_{pkj\tau} + B_{pkj\tau}\right)\right]$$

$$i \neq c; \quad p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$C_{ikt} \geq \sum_{\tau=1}^{t-LT(i,k)} \left[\sum_{j=1}^{N} R(i,j)\left(x_{pkj\tau} + I_{pkj\tau} + B_{pkj\tau}\right)\right] i \neq c;$$

$$p = 1,..,ENDP; i = 1,..,N \setminus ENDP; \quad k = 1,..,K; \quad t = 1,..,T$$

$$C_{ckt} \geq \sum_{\tau=1}^{t} \left[\sum_{j=1}^{N} R(c,j)\left(x_{pkj\tau} + I_{pkj\tau} + B_{pkj\tau}\right)\right]$$

$$p = 1,..,ENDP; c = 1,..,C; \quad k = 1,..,K; \quad t = 1,..,T$$

Validation of Mathematical Models

The fundamental MRP II models are used to make a requirement list with deterministic information like demand, lead time of products and component, etc. on an existing production line of a Malaysian company. The company, namely ABC (a given name), is producing air filter products for diverse air filtration system. The details of the company are found in Wazed et al. [21]. The same data with the layout information is also employed in proposed mathematical models to prepare a timely requirement schedule of the systems under investigation. Both the models are solved in Lingo systems with global solver, and the outputs are compared.

Primary data collected from the floor are used to compare the outcomes of the MRP II and proposed mathematical models. Validation of data were performed to ensure that these are for the right issue and useful. Data validation checks that the data is sensible before it is processed. The recorded data were scrutinized by the production engineers who are familiar with the specific processes and adjustment has been taken. The model validation is performed to test the overall accuracy of the model and the ability to meet the real value. Table I and Table II are showing the timely requirements of components generated respectively by the basic MRP II and mathematical models for the company.

Table I. Timely requirement of parts based on Basic MRP II

Part/Product	Period								
	1	2	3	4	5	6	7	8	9
AAI	0	0	0	0	0	0	0	50	0
Assembly	0	0	0	0	50	0	0	0	0
Gasket	0	0	0	0	0	0	200	0	0
Assembly A	0	0	0	50	0	0	0	0	0
Al Separator	0	0	200	0	0	0	0	0	0
Al Foil	0	100	0	0	0	0	0	0	0
Media	150	0	0	0	0	0	0	0	0

It is really a good matching found between the two schedules generated by the basic MRP II and modified models. The later bearing additional information of the location where to be available the parts in a time frame.

Table II. Timely requirement schedule generated by mathematical models

Machine /Stage	Part/ Product	Period								
		1	2	3	4	5	6	7	8	9
Folding	Al Foil	0	100	0	0	0	0	0	0	0
Folding	Media	150	0	0	0	0	0	0	0	0
Assembly	Assembly A	0	0	0	50	0	0	0	0	0
Assembly	Al Separator	0	0	200	0	0	0	0	0	0
Strapping	Assembly	0	0	0	0	50	0	0	0	0
Gasketing	Gasket	0	0	0	0	0	0	200	0	0
Packaging	AAI	0	0	0	0	0	0	0	50	0

Effect of Component Commonality

The basic mathematical models for multistage manufacturing are validated in a production line. In this section, the effect of component commonality is observed using the proposed commonality models and the outcomes are compared with their basic forms. The models are executed for 18 periods under various created scenarios. For the commonality models, we assumed two different scenarios (Table III). The complete mathematical models for commonality of the multistage system are shown in Figure 3:

Table III. Commonality design

Scenario	Component in Line 1	Component in Line 2	Common component	Layout
1	C	H	C	Figure 4a
	D	I	D	
2	A	E	A	Figure 4b
	B	F	B	

Effect of Commonality on Production Cost and Capacity Requirement

The authors have executed the models in Lingo system to observe the impact of common parts in production. It is considered that the demand (Table IV) and procurement lead time are known and constant. The cost of the product specific components and common components are known. Common parts usually require higher cost and processing time (i.e. processing cost) than the others. It is assumed that the common parts are able to fulfill the purpose of the replaced component. The other cost parameters are considered same under any scenario. Figure 5 shows the effect of cost of common parts on the total cost incurred and capacity. The timely requirement schedules of the dependent items for both of the cases are generated from the models.

Table IV. Timely demand of the end products

Period	9	10	11	12	13	14	15	16	17	18
Product SL	120	120	120	120	120	120	120	120	120	120
Product DL	140	140	140	140	140	140	140	140	140	140

Objective function

$$\text{Minimize} \quad z = \sum_{WC(P,K)} \sum_{I} \sum_{T} \left(v_i x_{pkit} + c_i C_{pkit} + q_i I_{pkit}\right) + \sum_{WC(P,K)} \sum_{I} \sum_{T} f_{pk}\left(y_{pkit} - \gamma_{pkit}\right) + \sum_{WC(P,K)} \sum_{T} c_{WC} OT_{pkt}$$

Subject to

$$I_{pkst-1} + \sum_{t=1}^{t-LT(p,k,c)} x_{pkst} - I_{pkst} + B_{pkst} - B_{pkst-1} \geq \sum_{t=1}^{t} \left[\sum_{j=1}^{N} R(c,j)\left(x_{pkjt} + I_{pkjt} + B_{pkjt}\right) \right] \quad p = 1,..,ENDP;\ c = 1,..,C;\quad k = 1,..,K;\quad t = 1,..,T$$

$$I_{pkit-1} + \sum_{t=1}^{t-LT(p,k,i)} x_{pkt} - I_{ikt} + B_{pkit} - B_{pkit-1} \geq \sum_{t=1}^{t-LT(i,k)} \left[\sum_{j=1}^{N} R(i,j)\left(x_{pkjt} + I_{pkjt} + B_{pkjt}\right) \right]$$

$$i \neq c;\quad p = 1,..,ENDP;\ i = 1,..,N \setminus ENDP;\quad k = 1,..,K;\quad t = 1,..,T$$

$$C_{ikt} \geq \sum_{t=1}^{t-LT(i,k)} \left[\sum_{j=1}^{N} R(i,j)\left(x_{pkjt} + I_{pkjt} + B_{pkjt}\right) \right] \quad i \neq c;\quad p = 1,..,ENDP;\ i = 1,..,N \setminus ENDP;\quad k = 1,..,K;\quad t = 1,..,T$$

$$C_{ckt} \geq \sum_{t=1}^{t} \left[\sum_{j=1}^{N} R(c,j)\left(x_{pkjt} + I_{pkjt} + B_{pkjt}\right) \right] \quad p = 1,..,ENDP;\ c = 1,..,C;\quad k = 1,..,K;\quad t = 1,..,T$$

$$LS(i) \leq M y_{pkit} \quad p = 1,..,ENDP;\ i = 1,..,N \setminus ENDP;\quad k = 1,..,K;\quad t = 1,..,T$$

$$I_{Pkit} \times B_{pkit} = 0 \quad p = 1,..,ENDP;\quad k = 1,..,K;\quad i = 1,..,N \setminus ENDP;\ t = 1,..,T$$

The capacity constraints:

$$\sum_{I} \left[U(p,k,i) x_{pkit} + ST(p,k,i)\left(y_{pkit} - \gamma_{pkit}\right) \right] - OT_{Pkt} + UT_{pkt} \leq 1 \quad p = 1,..,ENDP;\quad k = 1,..,K;\quad t = 1,..,T$$

$$OT_{Pkt} \times UT_{pkt} = 0 \quad p = 1,..,ENDP;\quad k = 1,..,K;\quad t = 1,..,T$$

$$y_{pkit-1} + y_{pkit} \geq 2\gamma_{pkit} \quad p = 1,..,ENDP;\ i = 1,..,N;\quad k = 1,..,K;\quad t = 1,..,T$$

$$\gamma_{pkit} \leq MU(p,k,i) \quad p = 1,..,ENDP;\ i = 1,..,N;\quad k = 1,..,K;\quad t = 1,..,T$$

$$\sum_{i=1}^{N} \gamma_{pkit} \leq 1 \quad p = 1,..,ENDP;\ k = 1,..,K;\quad t = 1,..,T$$

Non-negativity constraints:

All variables ≥ 0; $y_{pkit} = \{0,1\}$; $n = Integer$

Figure 3. Commonality Models for multistage production

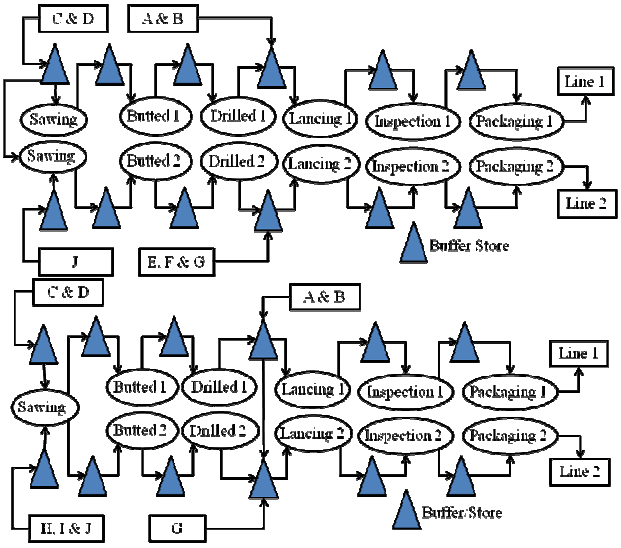

Figure 4. Production layout for commonality (a-Scenario1 and b-Scenario2)

Figure 5 shows that the cost of production and capacity requirements is always less for commonality cases. The cost increases with the cost ratio for both of the scenarios. Cost ration represents how much expensive the common parts in comparison to the substituted parts. For example, 1.10 means that the cost (both purchasing and processing) of common parts is 10 percent higher than the cost of the components it replaced. It is observed that commonality offers a better choice even if the cost (both purchasing and processing) of the common parts is 60 percent higher than the substituted parts (Scenario 1). The disparity in cost with cost ratio is not much sensitive in scenario 1 over the scenario 2. The cost saving in commonality models mainly comes from the processing cost. Inclusion of common parts at the lower level (Scenario 1) is always beneficial over the upper level (Scenario 2). Generally at the downstream of a production requires less parts and processing than the upstream components. This is the main reason of higher cost saving offer comes from the inclusion of common part at lower level than its successor. Since the commonality models require less setup due to less variety of parts, the capacity requirement is less.

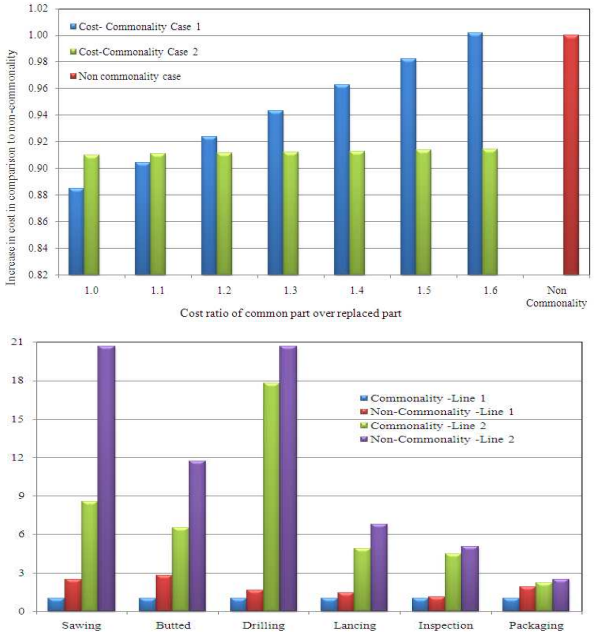

Figure 5. Effect of common parts on (a) costs and (b) capacity requirement (same setup and processing time)

Conclusion

From this study and analysis, the authors like to conclude that –

i. Under stable and stationary condition, the proposed models can provide exact planning like MRP II. Additionally, the parts routes are easily traced in the floor for each planning period.
ii. Use of common parts in manufacturing is always better over the non-commonality scenario in term of production cost and capacity requirements.
iii. The requirements of common parts are always higher than the individual part it replaces.
iv. The impact of applying component commonality at different stages is different due to the lead time dynamics in the system. Inclusion of common parts at the upstream is always beneficial than at the downstream of the production line.

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Technology Use in the Virtual R&D Teams

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Abstract:

Problem statement: Although, literature proves the importance of the technology role in the effectiveness of virtual research and development (R&D) teams for new product development. However, the factors that make technology construct in a virtual R&D team are still ambiguous. The manager of virtual R&D teams for new product development does not know which type of technology should be used.

Approach: To address the gap and answer the question, the study presents a set of factors that make a technology construct. The proposed construct modified by finding of the field survey (N = 240). We empirically examine the relationship between construct and its factors by employing the Structural Equation Modeling (SEM). A measurement model built base on the 19 preliminary factors that extracted from literature review. The result shows 10 factors out of 19 factors maintaining to make technology construct.

Result: These 10 technology factors can be grouped into two constructs namely Web base communication and Web base data sharing. The findings can help new product development managers of enterprises to concentrate in the main factors for leading an effective virtual R&D team. In addition, it provides a guideline for software developers as well.

Conclusion: The second and third generation technologies are now more suitable for developing new products through virtual R&D teams.

Key words: Collaboration teams, questionnaires performance, cross-functional teams, product development, structural equation modeling, measurement model, literature review,e virtual,

1 INTRODUCTION

A virtual team is defined as "a small temporary group of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, mainly with electronic information and communication technologies to carry out one or more organization tasks" (Ale Ebrahim et al., 2009b). Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities (Ale Ebrahim et al., 2011). The members of a virtual R&D team use different types of communication technology to complete the research beyond space, time and organizational boundaries (Ale Ebrahim et al., 2010). "We are becoming more virtual all the time!" is heard in many global corporations today (Chudoba et al., 2005). On the other hand, new product development (NPD) is widely recognized as a key to corporate prosperity (Lam et al., 2007). The specialized skills and talents needed for developing new products often remain locally in pockets of excellence around the company. Therefore, enterprises, have no choice but to disperse their

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new product development units to gain access into such dispersed knowledge and skills (Kratzer et al., 2005). As a result, enterprises are finding that internal development of all technologies needed for new products and processes are difficult or impossible. They must increasingly receive technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently begun to make a serious headway due to the rapid growth of a large variety of technologies. This means that virtuality in NPD is now technically possible (Leenders et al., 2003). Due to increasing and changing product features, by-and-large product development has become more complex, with increasing complexity in the supply chain. Therefore, more close collaboration between customers, developers, and suppliers has become vital. The foretold collaborations often involve individuals from different geographical locations that could now be brought together by using the various types of information technology (IT). IT offers a large number of benefits (Anderson et al., 2007). Although the use of the Internet for many purposes has received notable attention in the literature, little has been said about collaborative tool and effective virtual teams for NPD (Ale Ebrahim et al., 2009a). In addition, the literature did not reveal adequate focus on the factors which can construct a technological niche for a virtual R&D team for NPD. This aims to such a technological construct.

This paper is structured as follows. Firstly, based on prior research, we extracted the 19 factors of technology construct in the virtual R&D teams. Next, Structural Equation Modeling (SEM) was used as an analytical tool for testing the estimations and testing the technology construct measurement models. Then, we adjusted the preliminary technology construct model by fitting the model according to the SEM fitness indices and made a final measurement model. The paper infers with a discussion and future guidelines.

2 LITERATURE REVIEW

Virtual teams use digital communications, video and audio links, electronic whiteboards, e-mails, instant messaging, websites, chat rooms, etc. as substitutes for physical collocation of the team members (Baskerville and Nandhakumar, 2007, Pauleen and Yoong, 2001). Simple transmission of information from location *A* to another location *B* is not enough. However, a virtual environment presents significant challenges to effective communication (Walvoord et al., 2008). Being equipped with even the most advanced technologies is not necessarily sufficient to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be present for a team to succeed in the virtual world (Lurey and Raisinghani, 2001). Virtual teams are technology-mediated groups of people from different disciplines that work on common tasks (Dekker et al., 2008) and therefore, the way the information technology is implemented seems to make the virtual teams outcome more or less likely (Anderson et al., 2007). The virtual R&D team's instructor should choose the appropriate technology based on the purpose of the team (Ale Ebrahim et al., 2009d).

The factors which make technology construct in a virtual R&D team are still not clearly set in the literature. We extracted 19 important factors related to the technology construct, based on a comprehensive review on technology view in the virtual R&D team working. Table 1summarizes the factors and their supported references. E-mails and conference calls are generally known as first generation technologies whereas online discussion boards, Power Point presentations, video tools and online meeting tools are second-generation technologies. Third generation technology refers typically to web-enabled shared workspaces with the Intranet or Internet (Lee-Kelley and Sankey, 2008).

Table 1 Summary of the factors related to technology construct in virtual teams

Factor name	Factor descriptions	References
Tech1	Use internet and electronic mail	(Redoli et al., 2008, Pauleen and Yoong, 2001, Lee-Kelley and Sankey, 2008, Thissen et al., 2007, Townsend et al., 1998)
Tech2	Online meeting on need basis	(Chen et al., 2007, Lee-Kelley and Sankey, 2008, Pena-Mora et al., 2000, Thissen et al., 2007)
Tech3	Web conferencing	(Coleman and Levine, 2008, Thissen et al., 2007, Zemliansky and Amant, 2008, Ale Ebrahim et al., 2009d)
Tech4	Seminar on the Web	(Zemliansky and Amant, 2008)
Tech5	Shared work spaces	(Lee-Kelley and Sankey, 2008)
Tech6	Video conferencing	(Chen et al., 2007, Zemliansky and Amant, 2008, Townsend et al., 1998)

Tech7	Audio conferencing	(Chen et al., 2007, Lee-Kelley and Sankey, 2008, Zemliansky and Amant, 2008)
Tech8	Online presentations	(Lee-Kelley and Sankey, 2008, Townsend et al., 1998)
Tech9	Share documents (off-line)	(Coleman and Levine, 2008, Ale Ebrahim et al., 2009d, Townsend et al., 1998)
Tech10	Share what is on your computer desktop with people in other locations (Remote access and control)	(Thissen et al., 2007, Ale Ebrahim et al., 2009c, Townsend et al., 1998)
Tech11	Do not install engineering software (get service through web browser)	(Coleman and Levine, 2008, Kotelnikov, 2007, Shumarova, 2009)
Tech12	Access service from any computer (in Network)	(Thissen et al., 2007, Shumarova, 2009)
Tech13	Standard phone service and hybrid services	(Thissen et al., 2007, Ale Ebrahim et al., 2009d, Townsend et al., 1998)
Tech14	Access shared files anytime, from any computer	(Lee-Kelley and Sankey, 2008, Townsend et al., 1998)
Tech15	Web database	(Coleman and Levine, 2008, Zemliansky and Amant, 2008, Ale Ebrahim et al., 2009d, Townsend et al., 1998)
Tech16	Provide instant collaboration	(Coleman and Levine, 2008, Thissen et al., 2007)
Tech17	Software as a service (canceling the need to install and run the application on the own computer)	(Coleman and Levine, 2008, Thissen et al., 2007, Townsend et al., 1998)
Tech18	Virtual research center for product development	(Zemliansky and Amant, 2008, Townsend et al., 1998)
Tech19	Integratable/compatible with the other tools and systems	(Coleman and Levine, 2008, Kotelnikov, 2007, Townsend et al., 1998)

3 RESEARCH METHODOLOGY AND DATA COLLECTION

To build a measurement model of information technology construct in virtual R&D teams for new product development, we conducted a Web-based survey mainly in Malaysian and Iranian manufacturing enterprises, in a random sample of small and medium enterprises. Web-based survey method was selected because it is a cost-effective and quick method to obtain feedbacks from the beliefs of the respondents. The rapid expansion of Internet users has given Web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002, Ebrahim et al., 2010). A Likert scale from one to five was used. This set-up provided the respondents with a series of attitude dimensions. For each factor, the respondents were asked whether the factor is unimportant or extremely important using a Likert scale rating. The questionnaires were e-mailed to the managing director, R&D manager, new product development manager, project and design manager and appropriate personnel who were most familiar with the R&D activities within the firm.

Invitation e-mails were sent to each respondent, reaching 972 valid email accounts, with reminders following every two weeks up to three months. 240 enterprises completed the questionnaire, for an overall response rate of 24.7% (Table 2).

Table 2 Summary of online survey data collection

Numbers of e-mails sent to enterprises	3625
Total responses (Clicked the online web page)	972
Total responses / received questionnaire (%)	26.8
Total completed	240
Total completed / received questionnaire (%)	24.7

4 ANALYSIS AND RESULTS

Gerbing and Anderson (1988) suggested using confirmatory factor analysis (CFA) for scale development because it affords stricter interpretation of uni-dimensionality than what is provided by traditional approaches such as coefficient alpha, item-total correlations, and exploratory factor analysis. The evidence that the measures were uni-dimensional, whereby a set of indicators (factors) shares only a single underlying construct, was assessed using CFA (Anderson and Gerbing, 1988). According to Anderson and Gerbing (1988), after data collection, the measures' purification procedures should be used to assess their reliability, uni-dimensionality,

discriminant validity, and convergent validity. For reliability analysis, Cronbach's alpha was employed to each factor. From Table 3, all items with Cronbach's α greater than the threshold value of 0.6 were included in the analysis and the rest were omitted from analysis. Hence, the factors Tech1, Tech10, Tech11 and Tech13 were excluded from further analysis. In general, the reliability of the contents in the questionnaire exhibits good reliability across the samples.

Structural Equation Modeling (SEM) using AMOS 18 was employed for validating the measurement model. The statistical analysis were estimated simultaneously for both measurement and structural models (Dibrell et al., 2008). In order to ensure that the factors made the right construct, the measurement model was examined for its fit. Given this, the model was assessed for convergent and discriminant validity.

Convergent validity was established using a calculation of the factor loading, average variance extracted (AVE) and composite reliability (CR). The factors which have standardized loadings exceeding 0.50, were retained (Dibrell et al., 2008). The initial measurement model consisted of 19 factors (Tech1 to Tech19). After revising the measurement model by deleting Tech1, Tech10, Tech11 and Tech13, the AVE and CR were calculated. AVE larger than 0.5 is the threshold (McNamara et al., 2008). CR was calculated by squaring the sum of loadings, followed by division with the sum of squared loadings, plus the sum of the measurement error (Lin et al., 2008). CR should be greater than 0.6 (Huang, 2009). The measurement model had acceptable convergent validity since the calculated CR and AVE were 0.930 and 0.613, respectively.

Table 3 Summary of the final measures and reliabilities

Factor name	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Tech1	0.525	0.943
Tech2	0.755	0.939
Tech3	0.777	0.939
Tech4	0.717	0.940
Tech5	0.759	0.939
Tech6	0.722	0.940
Tech7	0.731	0.939
Tech8	0.780	0.939
Tech9	0.610	0.942
Tech10	0.576	0.942
Tech11	0.571	0.943
Tech12	0.686	0.940
Tech13	0.519	0.943
Tech14	0.624	0.941
Tech15	0.696	0.940
Tech16	0.642	0.941
Tech17	0.678	0.940
Tech18	0.649	0.941
Tech19	0.615	0.942

For discriminant validity, we used AMOS software using the Maximum Likelihood method (ML). The fitting indices were checked with their respective acceptance values (Table 4). We ran the AMOS for the model Ver1 (information technology construct with 15 factors), and found a non-significant chi-square value per degree of freedom (CMIN/DF = 7.232). Most of the remaining fit indices were not within the acceptable range. Thus, referring to the AMOS modification indices (MI), some of the factors which had the lowest factor loading or the same effect of remaining factor, were deleted. With this modification, the measurement model Ver2 had a significant chi-square per degrees of freedom (CMIN/DF = 4.767); other fit indices, RMSEA, RMR, and GFI were also in the acceptable range. Therefore, the best fitting model was the measurement model Ver2 (Figure 1) and it was used for further analysis.

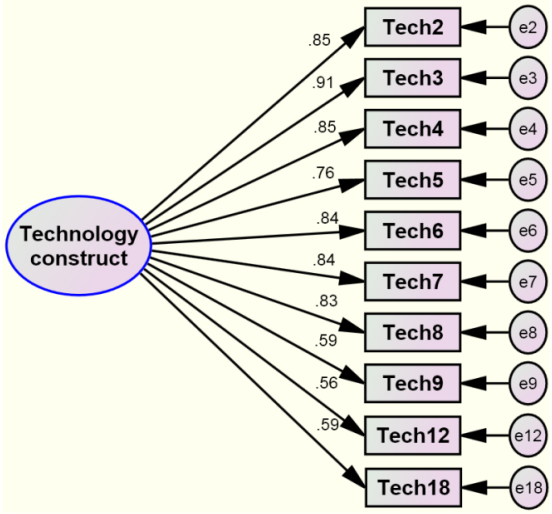


Figure 1 Measurement model Ver2

Table 4 Fitting indices (adopted from (Byrne, 2010))

Fit Indices	Desired Range
χ2 /degrees of freedom (CMIN/DF)	≤ 2.00
IFI (Incremental Fit Index)	≥ 0.90
CFI (Comparative Fit Index)	Coefficient values range from zero to 1.00, with values close to .95 showing superior fit
RMSEA (Root Mean Square Error of Approximation)	values less than .05 show good fit, and values as high as .08 represent reasonable fit, from .08 to .10 show mediocre fit, and those greater than .10 show poor fit.
Root mean square residual (RMR)	≤ 0.08
Goodness-of-Fit Index (GFI)	≥ 0.90
Normed Fit Index (NFI)	Coefficient values range from zero to 1.00, with values close to .95 showing superior fit
Relative Fit Index (RFI)	Coefficient values range from zero to 1.00, with values close to .95 showing superior fit
Tucker-Lewis Index (TLI)	Values ranging from zero to 1.00, with values close to .95 (for large samples) being indicative of good fit.

5 DISCUSSION ON VERIFIED MODEL

The final measurement was carried out based on measurement model ver2 by classifying the factors into two groups according to their relevant factor loading with a threshold value of 0.83. Referring to the Table 1, the proper name for each group can be Web-based communications and data sharing, respectively. From Figure 2, each factor loading with a value above 0.62 is significant. Overall, the final measurement model produced good fit indices (CMIN/DF = 2.889, RMR = 0.04, GFI = 0.929, RFI = 0.929, NFI = 0.949, TLI = 0.952, CFI = 0.966 IFI = 0.964, RMSEA = 0.089).

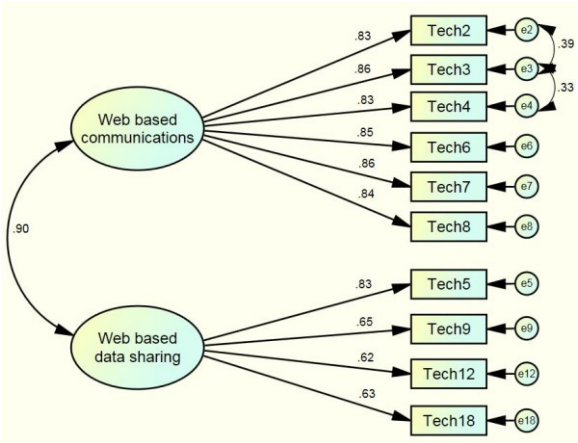
While fitting the information technology construct of the measurement model, the factors Tech14 (access shared files anytime, from any computer), Tech15 (web database), Tech16 (provide instant collaboration), Tech17 (software as a service (eliminating the need to install and run the application on the own computer) and Tech19 (can be integrated/compatible with the other tools and systems) were dropped. Modification indices (MI) based on regression weights showed that Tech17, Tech 18 and Tech19 were highly correlated, and therefore one representative (Tech18) from this group appeared to be adequate. Tech14 to Tech16 were strongly correlated with Tech12, and hence, the remaining factors represent the deleted ones.

The results of the final measurement model of information technology construct in virtual R&D team for new product development, showed the share of two main contrasts, which were strongly correlated to each other:

1. Web-based communications consists of online meetings on a required basis, web conferencing, seminars on the web, video conferencing, audio conferencing and online presentations.
2. Web-based data sharing consists of shared work spaces, shared documents (off-line), access service from any computer (in network) and virtual research centre for product development.

According to Lee-Kelley and Sankey (2008), these two constructs belong to the second and third generation technology. Well-equipped virtual R&D team members with the appropriate technology make the teams more effective. Therefore, managers of NPD should provide the facilities and infrastructures for the virtual R&D teams to achieve higher levels of team effectiveness.

Figure 2 Final measurement model



6 CONCLUSIONS

This research explores the 19 factors related to communication strategy using information technology in virtual team environment. However, the factors which mainly contribute to the information technology construct in virtual R&D teams' communication for new product development were unknown in the preceding literature. The findings of this study will contribute some knowledge in the literature and build a foundation for further understanding of the technology elements in virtual R&D teams for new product development. The measurement model shows ten factors that made the information technology constructs. These ten factors can be sorted by their factor loading, which reflects the factor's weight. Therefore, the software developer or the managers of NPD are able to provide a better platform for virtual teams by concentrating on the main factors. The second and third generation technologies (refer to definition of Lee-Kelley and Sankey (2008)) are now more suitable for developing new products through virtual R&D teams.

Future research is needed to examine the effects of each factor to perform the virtual R&D teams whereas the other constructs of virtual teams such as process and people are taken into account. A new SEM is needed to demonstrative the relationships between factors-construct and construct-construct, which are not yet investigated.

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IEMS Vol. 10, No. 2, pp. 109-114, June 2011.

The Effectiveness of Virtual R&D Teams in SMEs: Experiences of Malaysian SMEs

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Received, January 12, 2011; Revised, April 12, 2011; Accepted, April 19, 2011

Abstract. The number of small and medium enterprises (SMEs), especially those involved with research and development (R&D) programs and employed virtual teams to create the greatest competitive advantage from limited labor are increasing. Global and localized virtual R&D teams are believed to have high potential for the growth of SMEs. Due to the fast-growing complexity of new products coupled with new emerging opportunities of virtual teams, a collaborative approach is believed to be the future trend. This research explores the effectiveness of virtuality in SMEs' virtual R&D teams. Online questionnaires were emailed to Malaysian manufacturing SMEs and 74 usable questionnaires were received, representing a 20.8 percent return rate. In order to avoid biases which may result from pre-suggested answers, a series of open-ended questions were retrieved from the experts. This study was focused on analyzing an open-ended question, whereby four main themes were extracted from the experts' recommendations regarding the effectiveness of virtual teams for the growth and performance of SMEs. The findings of this study would be useful to product design managers of SMEs in order to realize the key advantages and significance of virtual R&D teams during the new product development (NPD) process. This is turn, leads to increased effectiveness in new product development's procedure.

Keywords: Virtual Teams, New Product Development, Survey Finding, Small and Medium Enterprises.

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) are major contributors for industrial economies (Eikebrokk and Olsen, 2007). The significance of SMEs in economic growth has rendered SMEs a central element in much recent policymaking (Hoffman *et al*., 1998). SMEs appear to be appropriate units as network nodes due to their lean structures, adaptability to market evolution, active involvement of versatile human resources, ability to establish subcontracting relations and good technological level of their products (Mezgar *et al*., 2000). SMEs possess advantages with regards to flexibility, reaction time and innovation capacity, and therefore SMEs play a major role in the new economy (Raymond and Croteau, 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets and more in areas which would directly enhance their future competitive advantage such as R&D, which would generate knowledge, as well as in their employees' creativity to stimulate incremental innovations in existing technologies. A crucial trend for enabling the creation and transfer of new

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knowledge in and to SMEs is by the development of virtual collaborative environments and networks to increase their innovation abilities as a single unit and capabilities of the network as a whole (Flores, 2006). Virtuality has been presented as a solution for SMEs aiming to increase their competitiveness (Pihkala *et al*., 1999). Virtual teams reduce time-to-market for new products (May and Carter, 2001). Lead time or time-to-market has been generally accepted as one of the vital keys for success in manufacturing companies (Sorli *et al*., 2006).

Ale Ebrahim *et al*. (2009a, 2010) derived the strengths and weaknesses of virtual teams in SMEs in their recent comprehensive reviews. The effectiveness of virtual teams in Malaysian manufacturing SMEs has not been reported, and therefore, the main objective of this study is to present the primary benefits of virtual teams for the growth of SMEs. The scope of this study is limited to the experiences of Malaysian manufacturing SMEs' expertise, which involve virtual teams. In this paper, the effectiveness is related to the performance and collaboration within virtual teams in order to reduce costs and time of R&D projects. This paper presents a portion of the results obtained from an empirical research carried out during the past two years within manufacturing SMEs in Malaysia. In moving towards virtual R&D teaming, an understanding of existing practices is important. In this paper, a review of recent literature pertaining to virtual R&D teams is presented, whereby the primary definition of virtual R&D teams and its relationship with SMEs are introduced. Following this, the research methodology and data analyses are detailed, and the directions for future research are presented in the final section of this paper.

2. VIRTUAL R&D TEAMS AND SMEs

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams, which interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and their works are coordinated mainly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel *et al*., 2005). Among the different definitions of virtual teams, the following concept is one of the most widely accepted definitions (Ale Ebrahim *et al*., 2009c): "Virtual teams are small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks" (Ale Ebrahim *et al*., 2009b). Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities. The members of a virtual R&D team utilize different degrees of communication technology to complete the research without space, time and organizational boundaries.

SMEs are not scaled-down versions of large companies as they possess different characteristics which distinguish them from large corporations. SMEs vary across different countries and cultures, and they are independent, multi-tasked and cash-limited as well as based on personal relationships and informality. Additionally, SMEs are managed actively by the owners, highly personalized, largely localized within their areas of operation and are largely dependent on internal sources for financial growth (Perrini *et al*., 2007). In order to survive in the global economy, SMEs have to improve their products and processes by exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso *et al*., 2003). Therefore, if small firms intend to create a step change in their technological and innovation base, they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to cooperate with external partners to compensate for other competencies and resources. This is especially the case for R&D, in which SMEs face specific problems compared with large firms (Pullen *et al*., 2008). Levy *et al*. (2003) stated that SMEs are knowledge creators; however, they are poor in knowledge retention. They need to be proactive in knowledge sharing arrangements to recognize that knowledge has value, and the value added is derived from knowledge exchange (Egbu *et al*., 2005). Virtual R&D teams can provide such knowledge sharing. There is a general movement towards virtual R&D teams, as virtual R&D teams facilitate the spreading of risks and sharing or costs among a network of companies (Gassmann and Von Zedtwitz, 1999, Kratzer *et al*., 2005). Hence, virtual teams are important mechanisms for organizations such as SMEs seeking to leverage scarce resources across geographic and other boundaries (Munkvold and Zigurs, 2007).

3. METHODOLOGY

The data for this research was gathered from desk study and survey. Web-based questionnaires were designed and delivered to Malaysian manufacturing SMEs, which included close-ended and open-ended questions. This study clustered one open-ended question. Clustering involves searching the data for related categories with similar meaning. This analysis is known as Thematic Analysis since the main purpose during the start of the analysis is to look for themes. When a set of themes is formed, more advanced analyses can be employed to look for clusters and patterns among them (Abdul Rashid, 2009). In this analysis, any sentences which provide significant meaning were extracted and organized into different categories.

4. DATA COLLECTION AND ANALYSES

The research was targeted at manufacturing SMEs within Malaysia, which employed virtual teams in their organizations. Online questionnaires were sent to relevant SMEs in order to obtain the viewpoints from experts involved with virtual teams in SMEs. Denscombe (2006) encouraged social researchers to use web-based questionnaires with confidence, and therefore online questionnaires were distributed to SMEs in Malaysia via email. The participants were directed to a website, and the surveys were completed online.

The questionnaires consisted of three sections, as follows:

a) Demographic information: The results obtained from this section enable the selection of suitable enterprises which complied with the definition of SMEs.

b) Current status of virtual teams: The first question in this section clarified the utilization of virtual teams in the enterprises. Respondents who selected "No" in answer to the question indicate that the organizations did not possess experience with virtual teams, and were directed to Section C in the questionnaires. The final open-ended question which concerns the effectiveness of virtual teams on the organization's growth and performance, were analyzed in this research.

c) Requirements for establishing virtual teams: The results of this section was not included in this research.

The surveys were tested preliminarily among 12 experts, followed by improvements, modifications and distribution. Finally, questionnaires consisting of open and close-ended questions were distributed to 356 Malaysian manufacturing SMEs. The major target groups with regards to the size of the organization and industrial field were Managing Directors, R&D Managers, New Product Development Managers, Project and Design Managers as well as appropriate personnel who were involved significantly with R&D issues in the organizations. A total of 74 usable questionnaires were received, which represented a 20.8 percent return rate. The response rate was deemed satisfactory since accessing high-rank personnel was difficult. Table 1. It was found that a total of 42 SMEs fulfilled the criteria of this research and therefore the remaining respondents were dropped from the analysis. Descriptive statistics were used to analyze the responses. Table 2 shows the frequency of using virtual teams among the sampled Malaysian SMEs. The results showed that 33.3% SMEs employed virtual teams. This indicates that applications of virtual teams in manufacturing SMEs are still in its infancy.

Table 1. Summary of online survey data collection.

Number of emails sent to Malaysian Firms	2068
Total Responses (Click the online web page)	356
Total Responses/Received questionnaire (%)	17.2
Total Completed	74
Total Completed/Received questionnaire (%)	20.8

It is known that open-ended questions provide fewer prompts and impose the fewest limits. It is for these reasons open-ended questions evoke the most authentic possible responses from respondents (Bobrow, 1997). Open-ended questions are good for prompting a respondent's attitude or feelings, likes and dislikes, memory recalls, opinions, or to request for additional comments. However, open-ended questions are time-consuming and particularly difficult to answer. After considering all advantages and disadvantages, only a few open-ended questions were used in the online questionnaires. In this research, only one open-ended question was considered, which was: *Please explain the total effectiveness of virtual team system/tool on the company's growth and performance, before and after implementation?*

Table 2. Cross-tabulation between country and virtual teams.

	Using Virtual Team		Total
	Yes	NO	
Count	14	28	42
%	33.3%	66.7%	100.0%

5. RESPONDENTS' COMMENTS

It was found that a great majority of the respondents answered the open-ended questions. Summarizing the results of open-ended questions was not simple due to the different levels of management and individuals, subjective wording and phrasing of the responses. However, several good comments were selected, and are shown as quotes in Table 3. The comments represent the actual experiences of the respondents, which are in accordance with (Ebrahim *et al*., 2010, May and Carter, 2001, Bouchard and Cassivi, 2004). The virtual teams' managers were a good source to confirm the benefits of virtuality due to their experiences. Since open-ended questions provide a rather qualitative information, simple thematic analysis was particular suitable to extract information from such questions. In this research, simple thematic analysis was performed by conducting two levels of clustering analysis. Thematic analysis is commonly used by qualitative researchers and is usually recognized as a tool rather than a method (Abdul Rashid, 2009). In this analysis, the data were clustered into two levels, whereby lower level is Level 2, and higher level is Level 1. Level 1 was then identified as theme. Table 4 shows the clusters and theme generated from the simple thematic analysis. From this analysis, it was found that

Table 3. Comments on the effectiveness of virtual teams for the company's growth and performance (Compare before and after implementation).

Case No.	Respondents' comments
1	Cost saving, time saving, and great convenience. These will enhance the flow of the projects of a company and speed up the progress of our work.
2	Reduce time consumption
3	Time and cost are saved.
4	Since we have different manufacturing location around the world, our marketing department is located away from R&D, the virtual tools are the one that brings us closer and helps in decision making, faster product release and meeting customer satisfaction.
5	Virtual team system/tool is merely ASSISTANCE to the current workload.
6	Save time, money and energy
7	In my opinion, virtual team can make a good connection between the entire assets of organization.
8	With start virtual team system we improved in my performance
9	The virtual team system/tool is effective and can be helpful
10	In both it is seriously important.
11	1) The company could growth faster, due to overcoming to distance and time by using virtual system 2) If system will be managed in an effective manner, the performance is increased due to power of the tools
12	We did some activities in our company to reduce costs as follows : 1-We arranged virtual network suppliers 2-They arranged R&D teams for our orders 3-our R&D department manage overall activities then we can reduced employees from 50 to less than 20
13	1) Capable for attracting experts and knowledge workers 2) declining ineffectual face to face meetings-improving work environment-Reducing time of trips
14	After correct implementation and good training of users, the growth of company is about 6 from 10 (10 is excellent and 0 is bad)
15	In my opinion it is impossible to work without such systems in the extremely mobile world we face these days.
16	Reduce unnecessary time waste and expedite product outcome
17	We demonstrate a positive annual trend in all factors important to us.
18	There is some effect but might be more effective while internal works are considered. In the case of international cooperation it depends strongly on consortiums formed for project executions

there are four main benefits of virtual team/tool on the growth and performance of enterprises. These benefits are: reduced R&D costs and time, more effective R&D, better output and increased coordination.

6. CONCLUSIONS

Despite the enormous benefits of employing virtual R&D teams in manufacturing SMEs, the application of virtual teams by most enterprises is still in its infancy. The study showed that one-third of Malaysian manufacturing SMEs have employed virtual R&D teams. Competitive advantage is now becoming available to SMEs through geographically open boundaries created by virtual teams. Existing practices within Malaysian manufacturing SMEs experts, who were involved with virtual teams, proved four-fold benefiting from the cross-functional virtual R&D teams, namely: 1-Reduced R&D cost and time, 2-More effective R&D, 3-Better output, 4-Increased coordination. Virtual R&D teams give better team outputs, reduce time-to-market, reduce travel costs and demonstrate the ability to tap selectively into centers of excellence. Additionally, virtual R&D teams enable the use of the best talents regardless of location, giving a greater degree of freedom to individuals, shorter development times, and quicker response to changing business environments as well as higher team effectiveness and coordination. Therefore, the decision for setting up virtual R&D teams in SMEs is not a choice, but a necessity.

This paper is probably the first to present an empirical research on virtual R&D teams, which is limited to Malaysian manufacturing SMEs. Future research is needed to investigate the four-fold benefits of virtual R&D teams by a larger sample from different

sectors. Although several studies have been carried out on the use of virtual R&D teams in large companies, applications within SMEs remain undocumented. Hence, future research should be focused on this gap and to search for a virtual collaborative system for SMEs which are dispersed geographically. Such a collaborative system should virtually link SMEs to enable the engaging members to focus on their specialized tasks as well as share their knowledge and experience (information resources). This will create agile manufacturing environments and enterprises.

Table 4. Clustered theme and cluster extracted from Table 3 (virtual team effectiveness).

No.	Cluster Level 1 /Theme	Cluster Level 2
1	Reduced R&D cost and time	Cost saving, Time saving Reduce time consumption Faster product release Reduced employees Reducing time of trips Reduce unnecessary time wastage
2	More effective R&D	Speeds up work progress Great convenience Facilitates decision-making Assists the current workload Improved performance Virtual team system/tool is effective Capable of attracting experts and knowledge workers
3	Better output	Enhances the flow of projects of a company Meets customer satisfaction Increases performance Improves work environment Expedites product outcome Demonstrates a positive annual trend
4	Increased coordination	Brings us closer Good connection between the entire assets of organization

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African Journal of Business Management Vol. 4(11), pp. 2368-2379, 4 September, 2010
Available online at http://www.academicjournals.org/AJBM
ISSN 1993-8233 ©2010 Academic Journals

Full Length Research Paper

Virtual R&D teams and SMEs growth: A comparative study between Iranian and Malaysian SMEs

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Accepted 13 July, 2010

This paper explores potential advantages of using virtual teams for small and medium-sized enterprises (SMEs) with a comprehensive review on various aspects of virtual teams. Based on the standing of the pertinent literatures, attempt has been made to study the aspects by online survey method in Iran and Malaysia. In both countries, SMEs play an important role in their economies, employments, and capacity building. Virtual R&D team can be one of the means to increase SMEs efficiency and competitiveness in their local as well as global markets. In this context, surveys have been conducted to evaluate the effects of virtuality to the growth of SMEs. The study addresses some differences between two countries in engaging virtual research and development (R&D) teams in their SMEs. It is observed that there is a significant difference between the SMEs turnover that employed virtual team and that did not employ the virtual team. The way for further studies and recommend improvements are proposed.

Key words: Virtual R&D team, small and medium enterprises, survey, developing countries.

INTRODUCTION

Faced with the challenges like increased globalization of markets and technological change, SMEs need reinforced support through transnational research cooperation to enhance their innovation and research investment. SMEs' survival depends on their capability to improve their performance and produce products that could meet international standards (Gomez and Simpson, 2007). In other words, a certain level of competitiveness appears to be a prerequisite for an SME's survival when dealing with dynamic conditions in the business environment. To compete with global competition and, overcome the rapid technology change and product variety proliferation in the new manufacturing environment, SMEs must be able to sustain product innovation (Laforet, 2007). Internationalization holds much potential for the growth of SMEs (Lu and Beamish, 2006). One very important trend to enable new knowledge creation and transfer in-and-to SME's is the development of collaborative environments and networks to increase their innovation capabilities as a single unit and also the and also the capabilities of the network as a whole (Flores, 2006). Participation in networks has nowadays become very important for any organization that strives to achieve a differentiated competitive advantage, especially if the company is small or medium sized (Camarinha-Matos et al., 2009). E-collaboration is related to better operational and business performance (Rosenzweig, 2009).

O'Regan et al. (2006a) investigated in a sample of 207 manufacturing SMEs and found a positive correlation between R&D investment and technological change in products and processes in firms with static or declining sales. Kuo and Li (2003) argue that the empirical result in Taiwan's SMEs indicates that a firm's likelihood in undertaking foreign direct investment (FDI) reaches a maximum when its R&D intensity reaches 11.08%; hence a strong quadratic relationship between R&D intensity in SMEs and FDI exists. O'Regan et al. (2006a), after discussions with Managing Directors of six organizations suggested that, in general, investment in R&D for development of a number of new products introduced the need to meet technological changes in both processes and products and the importance of prototype development are the most important attributes of innovation in manufacturing SMEs. Gassmann and Keupp (2007) found

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that managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage (e.g., in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in already existing technologies).

Global market requires short product development times, and so SMEs are also forced into transition from sequential to concurrent product development (Kusar et al., 2004). SMEs are key actors in the innovation system and the economy of a country. Despite their limitations in size, they make a lot of creativity in products and services they provide through R&D. Therefore, networking seems to be one of strategic solutions for technology based companies in order to give them a competitive advantage and the ability to tap into the knowledge base of other network partners. Putting an SME in the way to Information Society or in the way to making the best ICT investment in terms of economic return through company benefits is more of an art than engineering (Redoli et al., 2008). Lawson et al. (2006) study focuses on R&D in SMEs, and consequently provides novel insights currently lacking in the published literature.

The first step of this paper provides a primary definition of virtual teams; the importance of SMEs, the major characteristics of SMEs, differences in R&D between SMEs and large firms, SMEs and virtual teams working, based on comprehensive literature review of recent articles. On the next step, after over viewing of SMEs in Iran and Malaysia, research hypothesis, methodology and data collection, survey results are described. Lastly a guide line for future study evolved. It is argued that the establishing of virtual teams should be given consideration in the management of SMEs. Although computers widespread use for personal applications, very few programming frameworks exist for creating synchronous collaborative applications between SMEs.

Virtual teams

A virtual team is a temporary group of professionals that work together towards a common goal such as realizing a new product, a joint project etc., and that uses computer networks as their main interaction environment (Camarinha-Matos et al., 2009). It is a worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working (Anderson et al., 2007). Virtual teams comprised members who are located in more than one physical location. This team trait has fostered the extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs (Peters and Manz, 2007). Gassmann and Von Zedtwitz (Gassmann and Von Zedtwitz, 2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies, e-mail, video-conferencing, telephone, etc. (Hertel et al., 2005). Different authors have identified diverse areas. From the perspective of Leenders et al. (2003) virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organizations. Lurey and Raisinghani (2001) defined virtual teams - groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries. Amongst the different definitions of a virtual team the following concept from which the term employed in this paper is one of the most widely accepted definitions: (Powell et al., 2004), ''virtual teams are groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks ''.

SMEs definition

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from country to country (O'Regan and Ghobadian, 2004). Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition for SMEs (Deros et al., 2006). Table 1 illustrates the definition of SMEs in selected countries. In absence of a definitive classification, a consensus has been developed around the EC criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria (employee numbers (up to 250 employees), turnover and balance sheet statistics) (Tiwari and Buse, 2007). While turnover and balance sheet statistics are parts of the criteria, the overriding consideration in practice appears to be employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small to medium-sized firm. This study use Malaysian SME definition which is more limited than Iranian ones.

The importance of SMEs

The importance of small and medium-sized enterprises (SMEs) in economic growth has made them central elements in recent policymaking (Hoffman et al., 1998). SMEs are a major part of the industrial economies (Robles-Estrada and Gómez-Suárez, 2007; Eikebrokk and Olsen, 2007). Their survival and growth has therefore been a prominent issue. Beck et al. (2005) explored the relationship between the relative size of the small and medium enterprise (SME) sector, economic growth, and poverty alleviation using a sample of 45 countries, and found a strong, positive association between the importance of SMEs and GDP per capita growth. SMEs can successfully enter the global market if they can fulfill the customer needs regarding features and quality of products (Kusar et al., 2004). Acs et al. (1997) argued that small firms are indeed the engines of global economic growth. SMEs play an important role to promote economic development. SMEs in the beginning of R&D activities always face capital shortage and need technological assistance. In most countries, SMEs dominate the industrial and commercial infrastructure (Deros et al., 2006). More importantly SMEs play an important role in foreign direct investment (FDI) (Kuo and Li, 2003). Many economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance (Schröder, 2006). In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003). China's recent rapid growth is also linked to the emergence of many new small firms in village townships and in coastal areas, often in new industries (Acs et al., 1997).

SMEs seem to be appropriate units to behave like network nodes because of their lean structure, adaptability to market evolution, active involvement of versatile human resources, ability to establish sub-contracting relations and good technological level of their products (Mezgar et al., 2000). In the light of the above, SMEs have advantages in terms of flexibility, reaction time, and innovation capacity that make them central actors in the new economy (Raymond and Croteau, 2006). Gassmann and Von Zedtwitz (2003) based on 204 interviews with R&D directors and project managers in 37 technology-intensive multinational companies have shown five trends in organizing virtual R&D teams which are :

1. Continued internationalization of R&D will further increase the importance of and reliance on virtual R&D teams.
2. Virtual R&D teams will better integrate talent in newly industrialized countries.
1. Advances in information and communication technologies will further enhance the functionality of virtual teams.
2. Relative costs of running virtual R&D projects will decrease due to learning curve effects.
3. Highly decentralized virtual R&D teams will gain importance in open system architectures such as internet-based applications.

Susman et al. (2003) have probed more deeply than existing theories into the psychological and social dynamics of virtual teams and propose a model that articulates the processes that intervene between recognition of a misalignment, and appropriations that reduce or eliminate them. From the human resources point of view, SMEs' employees are given the authority and responsibility in their own work areas that can create cohesion and enhance common purposes amongst the workforce to ensure that a job is well done (Deros et al., 2006). In order to implement an appropriate knowledge management strategy in SMEs, cultural, behavioral, and organizational issues need to be tackled before even considering technical issues (Nunes et al., 2006). Acs et al. (1997) further argue that the international diffusion of SMEs innovations are important for global economic welfare. The traditional independence of small firms is being replaced by a network environment (Hanna and Walsh, 2002). Generally speaking three types of technologies are picked up by SMEs: small scale technologies, labor intensive technologies and specialized high technology know-how (Acs and Preston, 1997). Creating networks in the cycle of the management of these technologies is of a high importance.

The major characteristics of SMEs

In order to have a better understanding of SMEs, a brief knowledge of the characteristics of SMEs is a must. The major characteristics of SMEs are listed in Tables 2 and 3.

Dickson and Hadjimanolis (1998) state that since small companies typically lack some of the essential resources for innovation they have to acquire them from external sources, such as other companies, technical institutions, etc. Therefore, the management of inter-organizational relationships and networking in general may well be critical for the successful development in small companies. It is also important that the companies have the ability to network. As firms become 'networked' the critical capabilities are moving from within to between firms, and innovation will need to move too (Hanna and Walsh, 2002). Cooperative R&D is a useful way to overcome the lack of internal business resources and to improve innovativeness and competitiveness, particularly SMEs (Okamuro, 2007).

Table 1. Definition of SMEs in selected countries (adapted from Ale Ebrahim et al., 2009).

Country	Category of enterprise	Employee numbers	Turnover	Other measures
European Commission	Small	10-50 employees	Less than € 10 (13.5 USD) million turnover	Balance sheet total : Less than € 10 million balance sheet total
	Medium	Fewer than 250 employees	Less than € 50 (67.6 USD) million turnover	Balance sheet total : Less than € 43 million balance sheet total
Iran	Small	Less than 10* Less than 50**		
	Medium	10-100* 50-250**		
Malaysia	Small	Between 5-50 employees	Between RM 250,000 (75,000 USD) and less than RM 10 (3 USD) million	
	Medium	Between 50-150 employees	Between RM 10 (3 USD) million and RM 25 (7.5 USD) million	

*(CBI, 2009); **(ISIPO, 2009).

Table 2. Some of the major advantages of SMEs.

Advantage	Reference
Generally dominated by the entrepreneur (owner-manager)	(Jones and Macpherson, 2006; Bougrain and Haudeville, 2002; Love and Irani, 2004)
Able to respond quickly to customer requests and market changes, Customers focused	(Jones and Macpherson, 2006; Canavesio and Martinez, 2007; Huang et al., 2004)
Flexible and fast-response to change, easily adaptive to new market conditions , dynamic in behavior, developing customized solutions for partners and customers	(Deros et al., 2006; Sarosa, 2007; Abdul-Nour et al., 1999).
Concentrated production and sales in their home country	(Narula, 2004; Perrini et al., 2007).
Driven by client demands	(Lawson et al., 2006; Deros et al., 2006; Axelson, 2005)
Quick decision making process (decisions are made by an individual or a small number of people, or a single individual)	
Strongly correlated and inter-related with respect to Innovation and entrepreneurship	(Robles-Estrada and Gómez-Suárez, 2007; Gray, 2006; Gunasekaran et al., 1999)
High innovatory potential	
More extensive use of external linkages for Innovate.	(Laforet and Tann, 2006; Hoffman et al., 1998; Barnett and Storey, 2000)
Un bureaucratic processes, flat and flexible structures	(Deros et al., 2006; Levy and Powell, 1998; Massa and Testa, 2008)
Strong inter and intra-firm relationships , managing a great amount of information	(Carbonara, 2005; Chen et al., 2007)
Good at multi-tasking	(Schatz, 2006; Axelson; 2007)
Focused on gaining instant gratification with technology solutions.	(Schatz, 2006)
Informal and dynamic strategies	(Sharma and Bhagwat, 2006)
Capable of going international early and rapidly	(Gassmann and Keupp, 2007)
Possessing tight control over production processes due to close management involvement	(Levy and Powell, 1998)
Productive	(Beck et al., 2005)
Knowledge creating	(Egbu et al., 2005; Levy et al., 2003)
Capable of fast learning and adapting routines and strategy	(Axelson, 2005)
Great potential to adapt new production methods	
Creating astute alliances, networking	(Dijk et al., 1997; Massa and Testa, 2008; Karaev et al., 2007)

Table 3. Some of the major disadvantages of SMEs.

Disadvantage	References
Scarce resources and manpower	(Axelson, 2007; Abdul-Nour et al., 1999; Jansson and Sandberg, 2008)
Limited degree of information technology (IT) implementation	(Wang and Chou, 2008; Eikebrokk and Olsen, 2007; Sarosa and Zowghi, 2003)
Weak at converting research and development into effective innovation	(O'Regan et al., 2006a; O'Regan et al., 2006b)
Lacking some of the essential resources for innovation (poor innovative capabilities) Severe resource limitations in R&D	(Dickson and Hadjimanolis, 1998; Massa and Testa, 2008; Tiwari and Buse, 2007)
Strategy is based on low price, high quality offerings, rather than new product innovations	(Hobday et al., 2004)
Not having formal R&D activities	(Adams et al., 2006; Bougrain and Haudeville, 2002)
Strategy formulation on the basis of what available, lack a long run perspective	(Gomez and Simpson, 2007; Lindman, 2002)
Reliance on small number of customers, and operating in limited markets. Reactive and fire fighting mentality.	(Sharma and Bhagwat, 2006)
Rely on outdated technology, labor intensive and traditional management practices	(Deros et al., 2006; Beck et al., 2005; Caputo et al., 2002)
Lagging in the export, lack the resources necessary to enter foreign markets	(Mahajar et al., 2006'; Jansson and Sandberg, 2008)
Lack of formal competitor analysis, data collection during NPD processes.	(Woodcock et al., 2000)
Absolute size , fewer technological assets	(Narula, 2004)

Differences in R&D between SMEs and large firms

Small and medium-sized businesses are often edged out by their larger counterparts in today's competitive business environment. Until now, large multinational corporations enjoyed the advantage of having affordable resources spread out across the globe. Small and medium-sized enterprises (SMEs) typically suffer from lack of resources; their central role in the development of technology- and science-driven industries is paradoxical (Partanen et al., 2008). Therefore, virtual teams are able to provide a reliable structure to promote SMEs. Most products are multi-technology in nature, and multiple skills are needed; few companies, regardless of their size, can afford to maintain R&D facilities with world-class competencies in many different sectors (Narula, 2004). Innovation is equally important for large and small firms in the contemporary competitive and changing market (Dickson and Hadjimanolis, 1998). The ability of SMEs to meet growing consumer expectations is largely based on their capability to innovate and deliver new products at competitive prices. Innovation is a key driver of sustainable competitive advantage and one of the key challenges for SMEs (O'Regan et al., 2006b). Building global teams and Internet-related capabilities are now options for all companies, regardless of size and location (Bergiel et al., 2008). In every organization, regardless of size, profit, over the last decades, R&D teams have become increasingly virtual (Kratzer et al., 2005; Leenders et al., 2003).

On the other hand, some authors argue that large firms appear to have been more innovative rather than small firms (Tether, 1998). Especially in IT industry large firms create more IT innovation than do small firms (Patrakosol and Olson, 2007). In multinational companies, the use of dispersed constellations in R&D activities is seen to be

increasing (McDonough et al., 2001; Richtne and Rognes, 2008). Jeong (2003), in a survey of 179 US and 250 Chinese firms, explores the role of firm size in facilitating the relationship between multinational expansion and new product performance. The study shows that the firm size effects appear to be significant among Chinese firms, but not in the US sample. The article also shows that US firms can incorporate the benefits of international expansion into their new product development efforts, irrespective of their size. However, although large companies have sufficient resources for investing in innovation, they suffer from a variety of issues that may make them less innovative (Laforet, 2007); larger firms are able to avail themselves of the flexibility long enjoyed by SMEs (Narula, 2004).

SMEs and virtual teams working

Virtuality has been presented as one solution for SMEs aiming to increase their competitiveness (Pihkala et al., 1999). Karaev (2007) in a comprehensive literature has shown the benefits of establishing clusters as an efficient tool for overcoming the size limitations of SMEs. Geographical proximity brings so-called agglomeration effects in terms of higher specialization, innovation and knowledge transfer, which results in costs reduction and improving the competitiveness of industrial sectors, regions and nations. Small businesses must leverage the adoption process to maximize the speed and ease of technology transfer from its partners. Only through cooperation in the adoption of innovations can inter-organizational networks function optimally (Hausman, 2005). Past literature often hypothesized that SMEs did not innovate in formally recognized ways and that they made much more extensive use of external linkages (Laforet and Tann, 2006; Hoffman et al., 1998; Barnett and Storey, 2000). To survive in the global economy SMEs have to improve their products and processes exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). If small firms want to make a step change in their technological and innovation base they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to focus on core competences for efficiency matters; they need to cooperate with external partners to compensate for other competences and resources. This is especially the case in the field of new product development, where SMEs face specific problems compared to large firms (Pullen et al., 2008).

Despite the widespread publicity of information technology, the application of internet technology to upgrade and enhance the product design and business operation by most enterprises, especially for the SMEs, is still at its infancy (Zhan et al., 2003). Lin et al. (2007) found that although almost all senior executives and managers were committed to the IT investments in enterprise during the implementation stage, most of these organizations did not manage user resistance effectively. The SMEs are one of the sectors that have a strong potential to benefit from advances in ICTs and the adaptation of new business modes of operation. The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtually invention (Miles et al., 2000). The use of ICTs can be considered as key factors for innovation and entrepreneurship. ICTs are a must for SMEs to innovate (Redoli et al., 2008). Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). SMEs have lack of capital investment for systematic use of information, developing organization processes and technology development. Three out of the eleven organizations used the intranet for knowledge identification. This is basically a data warehouse with data on previous projects and employees (those involved in projects, together with their skills and competences) (Egbu et al., 2005). This indicates that organizations, especially SMEs, do not fully explore the potential benefits of IT for growth. Levy et al. (2003) state that SMEs are knowledge creators but are poor at knowledge retention. They need to be proactive in knowledge sharing arrangements to recognize that knowledge has value and the value added is derived from knowledge exchange (Egbu et al., 2005).

AN OVERVIEW OF SMES IN IRAN AND MALAYSIA

Before going to data collection and analyzing the results, an overview of the situation of SMEs in Iran and Malaysia is provided to increase knowledge about these developing countries. The current trend of economic growth and rapid industrial development has made Malaysia one of the most open economies in the world. Under the Ninth Malaysia Plan (2006-2010), the Government devotes and designs a SME development plan to help SMEs to meet the challenges in the competitive global business environment (Zulkifli-Muhammad et al., 2010).

The role of SMEs in Malaysia and Iran's economic development is well recognized. SMEs represent over 99% of total establishments, but contribute only 32% of gross domestic product (GDP), in comparison to over 40% GDP contribution in other regional economies such as Thailand, Taiwan and Korea and more than 55% in countries like China and Japan (SME Annual Report, 2006). Therefore, major opportunities for SMEs in Malaysia to expand their role are pending. Malaysian SMEs have not moved fast enough to their traditional role of developing new products. Same as Malaysia most SMEs in Iran are still conventional. Their school of thought belongs to the industrial age and their efforts are

not aligned with the requirements of the knowledge age. Today's changes require a new model of thought as a basic requirement (Jafari et al., 2007). Indeed, there are huge opportunities for SMEs to grow and become active and increase their level of contribution as the case of SMEs in developed economies by implementing virtual R&D teams in the NDP.

The purpose of choosing these two developing countries was due to the potential growth of SMEs and the creation of a network of SMEs that might be geographically dispersed, but virtually linked. Thus, the participating members focus on their specialized tasks but also share their knowledge and experience to create resources of an agile and flexible structure.

RESEARCH HYPOTHESES, METHODOLOGY AND DATA COLLECTION

The focus of the investigation is on virtual R&D projects in SMEs. Data for this research are gathered from the desk study and survey in Malaysian and Iranian SMEs. A web based questionnaire was designed and sent to Malaysian SMEs. Its translated Persian version was sent to Iranian manufacturing SMEs. Due to the fact that these countries adopt different definitions of SMEs depending on their business interests, the data were tailored accordingly. Based on these data analysis, some interpretations and formulation of the link between R&D virtual teams and SMEs performance from financial points of view are developed. Advanced statistical methods are used and analyses are carried out to examine the effect of virtuality on SMEs outputs.

This study attempts to identify the effect of virtuality in the growth of SMEs in Iran and Malaysia. Despite knowing that virtual environments can be created using the internet facilities and there could be similarities of such environments irrespective of geographical location, this study, however, also intended to identify if there is any significant difference between these countries. To summarize, the objectives of the survey attempted to examine two relevant hypotheses:

Hypothesis 1

Virtual team activities in SME are positively related to SME's growth.

Hypothesis 2

There is no significant difference between Iranian and Malaysian SMEs growth in which virtual teams are applied.

To that end a questionnaire was developed to collect data for this research. In order to achieve the objectives of the study an online questionnaire has been sent to relevant SMEs in both countries. The rapid expansion of internet users has given web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002). Denscombe's (2006) findings encouraged social researchers to use web-based questionnaires with confidence and the data produced by web-based questionnaires were equivalent to that produced by paper-based questionnaires. Another authors emphasized that the data provided by Internet methods were of at least as good quality as those provided by traditional paper-and-pencil methods (Gosling et al., 2004; Deutskens et al., 2006). However, minor differences occur between the two survey methods; online respondents provide more improved suggestions (Deutskens et al., 2006) and tended to be slightly longer than those from the paper version, and the differences are not statistically significant (Denscombe, 2008).

The main sampling targets were managing director, R&D manager, new product development manager, project and design manager and appropriate persons who were most familiar with the R&D issue in the firm. For better understanding, the questionnaire has been prepared in two different languages, English and Persian. The Iranian respondents were able to select either English version or Persian version of the questionnaire. Out of 947 respondents 210 (22.1%) firms responded to the questionnaire completely and the rest answered it partially. This response rate was satisfactory since accessing the managers is usually difficult. 91 firms met the criteria of SMEs definition for this research. The rest responses were deducted from the analysis.

A descriptive cross-tabulation statistic is done to find the frequency and relationship between the countries and virtual team as illustrated in Table 4. The result shows that Iranian SMEs employed virtual team in R&D activities more than double of Malaysian SMEs (71.4 and 33.3% respectively).

SURVEY RESULTS

Background of respondents

As virtuality is relatively a new idea and competent individuals should get involved, the job position of respondents in the company was the first aspect to be investigated as a background. The respondents to the survey were mainly the Managing Directors or the persons who were in charge of R&D and New Product Development of the companies. The results are presented in Table 5.

The second aspect investigated is the company size and turnover according to Malaysian SME definition which are different from that of Iranian ones. Figures 1 and 2 show that the respondents were mostly from small companies. Small-sized firms defined in this study have less than 50 full-time employees and less than $2.8 million turnover last year.

Hypotheses

The following hypothesis was formulated for conducting the significance test from the responses of SMEs.

Hypothesis 1: 'Employee virtual team in SME is positively related to SME's growth'

H_0: $\mu_1 - \mu_2 = 0$, there is no significant difference between the SMEs turnover that employed virtual team and did not employ virtual team.

H_1: $\mu_1 - \mu_2 \neq 0$, there is a significant difference between SMEs turnover that employed virtual team and did not employ virtual team.

The Fisher's exact test by using SPSS was employed for analyzing the test. The results in Table 6 show that the p-value is lower than 0.05 (significant level); hence the null

Table 4. Cross-tabulation between country and virtual team.

Country		With virtual team		Total
		Yes	No	
Iran	Count	35	14	49
	% within country	71.4	28.6	100.0
	% of total	38.5	15.4	53.8
Malaysia	Count	14	28	42
	% within country	33.3	66.7	100.0
	% of total	15.4	30.8	46.2
Total	Count	49	42	91
	% within country	53.8	46.2	100.0
	% of total	53.8	46.2	100.0

Table 5. Position of respondents in the company.

Position in the company	Frequency	Percentage (%)
Managing director	35	38.5
R&D manager	10	11.0
New product development manager	10	11.0
Project manager	11	12.1
Others (CEO, GM, QC manager, etc.)	25	27.5
Total	91	100

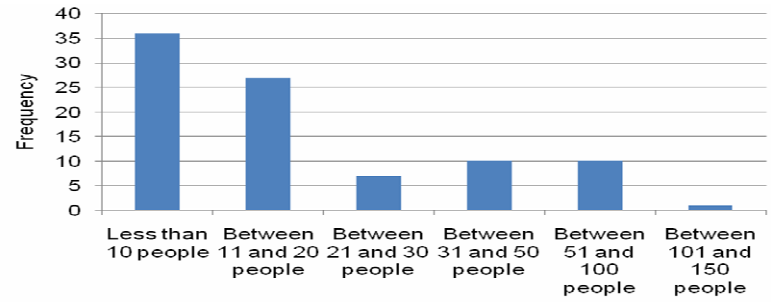

Figure 1. Background of respondents: number of employee (company size).

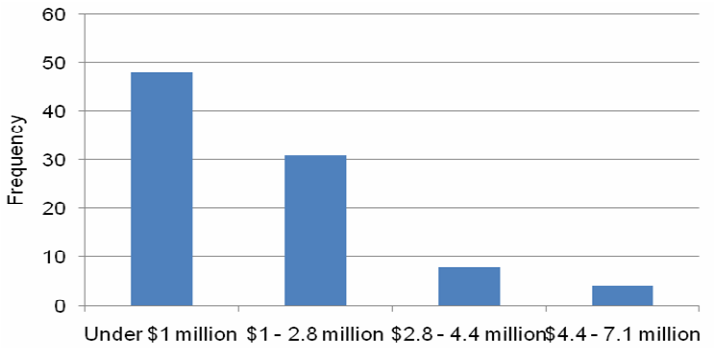

Figure 2. Background of respondents: company turnover.

Table 6. The fisher's exact test results.

Country	Test	Value	Exact significance of *P*-value. (2-sided)
Iran	Fisher's exact test	7.685	.033
	Number of valid cases	49	
Malaysia	Fisher's exact test	8.315	.022
	Number of valid cases	42	

Table 7. Test statistics results grouped by country.

		Turnover	Virtual team	
Mann-Whitney U		954.000	637.000	
Z		-.662	-3.614	
P-value (2-tailed)		.520	.000	
Ranks	**Country**	**N**	**Mean rank**	**Sum of ranks**
Turnover	Iran	49	44.47	2179.00
	Malaysia	42	47.79	2007.00
	Total	91		
With virtual team	Iran	49	38.00	1862.00
	Malaysia	42	55.33	2324.00
	Total	91		

the null hypothesis was rejected. In short, it can be concluded that there was a significant difference between the SMEs turnover that employed virtual team and did not employ virtual teams. Taking advantage of virtual teams enables companies to gain more revenue. Analysis of the survey for Iranian and Malaysian SMEs shows that SMEs which implemented virtual R&D teams have considerably higher growth compared to the traditional SMEs which face increased competition costs due to geographical limits.

Hypothesis 2: 'There is no significant difference between Iranian and Malaysian SMEs growth on employed virtual team'

H_0: $\mu_1 - \mu_2 = 0$, there is no significant differences between Iranian and Malaysian SMEs turnover on employed virtual team.

H_1: $\mu_1 - \mu_2 = 0$, there is a significant difference between Iranian and Malaysian SMEs turnover on employed virtual team.

The nonparametric Mann-Whitney *U* test for two independent samples (Iranian and Malaysian SMEs) was utilized for determining whether or not the values of a particular variable differ between two groups. From the Mann-Whitney *U* test results (Table 7), there was a significant difference between Iranian and Malaysia SMEs (*P*-value = 0. 000) on employed virtual team. Therefore, Mann-Whitney U test and descriptive cross-tabulation statistics (Table 4) results are with Iranian SMEs employed virtual team in R&D activities more than Malaysian SMEs. It means using virtual R&D teams in Iranian SMEs are more popular than Malaysian SMEs. Hypothesis 1 finding in Table 7 shows there was no significant difference between Iranian and Malaysia SMEs turnover (P-value = 0.520 > 0.05) on employed virtual team. It means higher revenue belonged to the SMEs that use virtual R&D teams. The negative Z statistics indicate that the rank sums are lower than their expected values.

Conclusion

This paper has presented the results from a comprehensive review and survey finding on different aspects of virtual teams in SMEs. We found that there was a significant difference between the SMEs turnover employed virtual teams and unemployed virtual teams. Furthermore, it was found that there was a significant difference between Iranian and Malaysia SMEs on employed virtual team. Iranian SMEs employed virtual team in R&D activities more than Malaysian SMEs (71.4 and 33.3 percent respectively). Many SMEs have limited recourses, and it is well-known for their dynamic behavior in contrast to the difficulty of diverting skilled personnel from day-by-day activities, to undertake process re-engineering and R&D. Therefore, applying virtual R&D team in SMEs is a foundation of high-growth SMEs.

The governments of developing countries have to be active in creating opportunities and networks for building SMEs' linkages and networks to succeed in R&D ventures. While larger organizations by their nature can afford the risk of making mistakes, small to medium enterprises (SMEs) are typically more vulnerable and, hence, need a structured low risk approach such as virtual R&D teams. With virtual R&D team the gap between large organizations and SMEs is closing and the pattern of winning in the market space is changing due to technological advances. Competitive advantage, which once belonged exclusively to the large firms, is now becoming available to SMEs through geographically open boundaries created by the virtual team. Reviewing the literature and survey finding shows that SMEs can achieve higher growth rates by the usage of virtual teams.

Most of the research activities relevant for SMEs do not encourage and support R&D collaboration and technology transfer. Benefiting from the cross functional virtual R&D teams beyond the organizations or countries are therefore vital to fill this gap, unlock growth opportunities for SMEs through research, and help them to carry out or outsource research in order to develop new technology based products, processes and services, explore research results, acquire technological know-how and train their employees to incorporate new developments. However, the literature so far has not paid adequate attention to the virtual R&D team activities in SMEs. While some studies have been conducted on model usage in MNCs and large companies, applications within SMEs remain largely un-documented. In the competitive era it is obvious that the survival of the SMEs will be determined first and foremost by their ability to manufacture/supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources. In order to face this challenge SMEs reinforce to create synergies via virtual R&D team that allows firms to overcome difficulties and succeeds. Therefore, managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage such as virtual R&D. Future research needs to design infrastructures to support virtual R&D team in SMEs. New ways of communicating and interacting among team members in virtual environments will necessitate being developed and implemented. Future research should concentrate on above mentioned gab as well as find a common and consistent definition for SMEs in order to make a universal platform to communicate in a smooth manner with the developed world.

ACKNOWLEDGEMENTS

This research was funded by a grant from the University of Malaya (Grant No. PS404/2009C), the authors acknowledge this support. In addition, the authors are grateful to the editors and two anonymous reviewers for their helpful and insightful on the first version of this document.

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IEMS Vol. 10, No. 2, pp. 109-114, June 2011.

The Effectiveness of Virtual R&D Teams in SMEs: Experiences of Malaysian SMEs

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Received, January 12, 2011; Revised, April 12, 2011; Accepted, April 19, 2011

Abstract. The number of small and medium enterprises (SMEs), especially those involved with research and development (R&D) programs and employed virtual teams to create the greatest competitive advantage from limited labor are increasing. Global and localized virtual R&D teams are believed to have high potential for the growth of SMEs. Due to the fast-growing complexity of new products coupled with new emerging opportunities of virtual teams, a collaborative approach is believed to be the future trend. This research explores the effectiveness of virtuality in SMEs' virtual R&D teams. Online questionnaires were emailed to Malaysian manufacturing SMEs and 74 usable questionnaires were received, representing a 20.8 percent return rate. In order to avoid biases which may result from pre-suggested answers, a series of open-ended questions were retrieved from the experts. This study was focused on analyzing an open-ended question, whereby four main themes were extracted from the experts' recommendations regarding the effectiveness of virtual teams for the growth and performance of SMEs. The findings of this study would be useful to product design managers of SMEs in order to realize the key advantages and significance of virtual R&D teams during the new product development (NPD) process. This is turn, leads to increased effectiveness in new product development's procedure.

Keywords: Virtual Teams, New Product Development, Survey Finding, Small and Medium Enterprises.

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) are major contributors for industrial economies (Eikebrokk and Olsen, 2007). The significance of SMEs in economic growth has rendered SMEs a central element in much recent policymaking (Hoffman *et al*., 1998). SMEs appear to be appropriate units as network nodes due to their lean structures, adaptability to market evolution, active involvement of versatile human resources, ability to establish subcontracting relations and good technological level of their products (Mezgar *et al*., 2000). SMEs possess advantages with regards to flexibility, reaction time and innovation capacity, and therefore SMEs play a major role in the new economy (Raymond and Croteau, 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets and more in areas which would directly enhance their future competitive advantage such as R&D, which would generate knowledge, as well as in their employees' creativity to stimulate incremental innovations in existing technologies. A crucial trend for enabling the creation and transfer of new

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knowledge in and to SMEs is by the development of virtual collaborative environments and networks to increase their innovation abilities as a single unit and capabilities of the network as a whole (Flores, 2006). Virtuality has been presented as a solution for SMEs aiming to increase their competitiveness (Pihkala *et al*., 1999). Virtual teams reduce time-to-market for new products (May and Carter, 2001). Lead time or time-to-market has been generally accepted as one of the vital keys for success in manufacturing companies (Sorli *et al*., 2006).

Ale Ebrahim *et al*. (2009a, 2010) derived the strengths and weaknesses of virtual teams in SMEs in their recent comprehensive reviews. The effectiveness of virtual teams in Malaysian manufacturing SMEs has not been reported, and therefore, the main objective of this study is to present the primary benefits of virtual teams for the growth of SMEs. The scope of this study is limited to the experiences of Malaysian manufacturing SMEs' expertise, which involve virtual teams. In this paper, the effectiveness is related to the performance and collaboration within virtual teams in order to reduce costs and time of R&D projects. This paper presents a portion of the results obtained from an empirical research carried out during the past two years within manufacturing SMEs in Malaysia. In moving towards virtual R&D teaming, an understanding of existing practices is important. In this paper, a review of recent literature pertaining to virtual R&D teams is presented, whereby the primary definition of virtual R&D teams and its relationship with SMEs are introduced. Following this, the research methodology and data analyses are detailed, and the directions for future research are presented in the final section of this paper.

2. VIRTUAL R&D TEAMS AND SMEs

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams, which interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and their works are coordinated mainly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel *et al*., 2005). Among the different definitions of virtual teams, the following concept is one of the most widely accepted definitions (Ale Ebrahim *et al*., 2009c): "Virtual teams are small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks" (Ale Ebrahim *et al*., 2009b). Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities. The members of a virtual R&D team utilize different degrees of communication technology to complete the research without space, time and organizational boundaries.

SMEs are not scaled-down versions of large companies as they possess different characteristics which distinguish them from large corporations. SMEs vary across different countries and cultures, and they are independent, multi-tasked and cash-limited as well as based on personal relationships and informality. Additionally, SMEs are managed actively by the owners, highly personalized, largely localized within their areas of operation and are largely dependent on internal sources for financial growth (Perrini *et al*., 2007). In order to survive in the global economy, SMEs have to improve their products and processes by exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso *et al*., 2003). Therefore, if small firms intend to create a step change in their technological and innovation base, they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to cooperate with external partners to compensate for other competencies and resources. This is especially the case for R&D, in which SMEs face specific problems compared with large firms (Pullen *et al*., 2008). Levy *et al*. (2003) stated that SMEs are knowledge creators; however, they are poor in knowledge retention. They need to be proactive in knowledge sharing arrangements to recognize that knowledge has value, and the value added is derived from knowledge exchange (Egbu *et al*., 2005). Virtual R&D teams can provide such knowledge sharing. There is a general movement towards virtual R&D teams, as virtual R&D teams facilitate the spreading of risks and sharing or costs among a network of companies (Gassmann and Von Zedtwitz, 1999, Kratzer *et al*., 2005). Hence, virtual teams are important mechanisms for organizations such as SMEs seeking to leverage scarce resources across geographic and other boundaries (Munkvold and Zigurs, 2007).

3. METHODOLOGY

The data for this research was gathered from desk study and survey. Web-based questionnaires were designed and delivered to Malaysian manufacturing SMEs, which included close-ended and open-ended questions. This study clustered one open-ended question. Clustering involves searching the data for related categories with similar meaning. This analysis is known as Thematic Analysis since the main purpose during the start of the analysis is to look for themes. When a set of themes is formed, more advanced analyses can be employed to look for clusters and patterns among them (Abdul Rashid, 2009). In this analysis, any sentences which provide significant meaning were extracted and organized into different categories.

4. DATA COLLECTION AND ANALYSES

The research was targeted at manufacturing SMEs within Malaysia, which employed virtual teams in their organizations. Online questionnaires were sent to relevant SMEs in order to obtain the viewpoints from experts involved with virtual teams in SMEs. Denscombe (2006) encouraged social researchers to use web-based questionnaires with confidence, and therefore online questionnaires were distributed to SMEs in Malaysia via email. The participants were directed to a website, and the surveys were completed online.

The questionnaires consisted of three sections, as follows:

a) Demographic information: The results obtained from this section enable the selection of suitable enterprises which complied with the definition of SMEs.

b) Current status of virtual teams: The first question in this section clarified the utilization of virtual teams in the enterprises. Respondents who selected "No" in answer to the question indicate that the organizations did not possess experience with virtual teams, and were directed to Section C in the questionnaires. The final open-ended question which concerns the effectiveness of virtual teams on the organization's growth and performance, were analyzed in this research.

c) Requirements for establishing virtual teams: The results of this section was not included in this research.

The surveys were tested preliminarily among 12 experts, followed by improvements, modifications and distribution. Finally, questionnaires consisting of open and close-ended questions were distributed to 356 Malaysian manufacturing SMEs. The major target groups with regards to the size of the organization and industrial field were Managing Directors, R&D Managers, New Product Development Managers, Project and Design Managers as well as appropriate personnel who were involved significantly with R&D issues in the organizations. A total of 74 usable questionnaires were received, which represented a 20.8 percent return rate. The response rate was deemed satisfactory since accessing high-rank personnel was difficult. Table 1. It was found that a total of 42 SMEs fulfilled the criteria of this research and therefore the remaining respondents were dropped from the analysis. Descriptive statistics were used to analyze the responses. Table 2 shows the frequency of using virtual teams among the sampled Malaysian SMEs. The results showed that 33.3% SMEs employed virtual teams. This indicates that applications of virtual teams in manufacturing SMEs are still in its infancy.

Table 1. Summary of online survey data collection.

Number of emails sent to Malaysian Firms	2068
Total Responses (Click the online web page)	356
Total Responses/Received questionnaire (%)	17.2
Total Completed	74
Total Completed/Received questionnaire (%)	20.8

It is known that open-ended questions provide fewer prompts and impose the fewest limits. It is for these reasons open-ended questions evoke the most authentic possible responses from respondents (Bobrow, 1997). Open-ended questions are good for prompting a respondent's attitude or feelings, likes and dislikes, memory recalls, opinions, or to request for additional comments. However, open-ended questions are time-consuming and particularly difficult to answer. After considering all advantages and disadvantages, only a few open-ended questions were used in the online questionnaires. In this research, only one open-ended question was considered, which was: *Please explain the total effectiveness of virtual team system/tool on the company's growth and performance, before and after implementation?*

Table 2. Cross-tabulation between country and virtual teams.

	Using Virtual Team		Total
	Yes	NO	
Count	14	28	42
%	33.3%	66.7%	100.0%

5. RESPONDENTS' COMMENTS

It was found that a great majority of the respondents answered the open-ended questions. Summarizing the results of open-ended questions was not simple due to the different levels of management and individuals, subjective wording and phrasing of the responses. However, several good comments were selected, and are shown as quotes in Table 3. The comments represent the actual experiences of the respondents, which are in accordance with (Ebrahim *et al*., 2010, May and Carter, 2001, Bouchard and Cassivi, 2004). The virtual teams' managers were a good source to confirm the benefits of virtuality due to their experiences. Since open-ended questions provide a rather qualitative information, simple thematic analysis was particular suitable to extract information from such questions. In this research, simple thematic analysis was performed by conducting two levels of clustering analysis. Thematic analysis is commonly used by qualitative researchers and is usually recognized as a tool rather than a method (Abdul Rashid, 2009). In this analysis, the data were clustered into two levels, whereby lower level is Level 2, and higher level is Level 1. Level 1 was then identified as theme. Table 4 shows the clusters and theme generated from the simple thematic analysis. From this analysis, it was found that

Table 3. Comments on the effectiveness of virtual teams for the company's growth and performance (Compare before and after implementation).

Case No.	Respondents' comments
1	Cost saving, time saving, and great convenience. These will enhance the flow of the projects of a company and speed up the progress of our work.
2	Reduce time consumption
3	Time and cost are saved.
4	Since we have different manufacturing location around the world, our marketing department is located away from R&D, the virtual tools are the one that brings us closer and helps in decision making, faster product release and meeting customer satisfaction.
5	Virtual team system/tool is merely ASSISTANCE to the current workload.
6	Save time, money and energy
7	In my opinion, virtual team can make a good connection between the entire assets of organization.
8	With start virtual team system we improved in my performance
9	The virtual team system/tool is effective and can be helpful
10	In both it is seriously important.
11	1) The company could growth faster, due to overcoming to distance and time by using virtual system 2) If system will be managed in an effective manner, the performance is increased due to power of the tools
12	We did some activities in our company to reduce costs as follows : 1-We arranged virtual network suppliers 2-They arranged R&D teams for our orders 3-our R&D department manage overall activities then we can reduced employees from 50 to less than 20
13	1) Capable for attracting experts and knowledge workers 2) declining ineffectual face to face meetings-improving work environment-Reducing time of trips
14	After correct implementation and good training of users, the growth of company is about 6 from 10 (10 is excellent and 0 is bad)
15	In my opinion it is impossible to work without such systems in the extremely mobile world we face these days.
16	Reduce unnecessary time waste and expedite product outcome
17	We demonstrate a positive annual trend in all factors important to us.
18	There is some effect but might be more effective while internal works are considered. In the case of international cooperation it depends strongly on consortiums formed for project executions

there are four main benefits of virtual team/tool on the growth and performance of enterprises. These benefits are: reduced R&D costs and time, more effective R&D, better output and increased coordination.

6. CONCLUSIONS

Despite the enormous benefits of employing virtual R&D teams in manufacturing SMEs, the application of virtual teams by most enterprises is still in its infancy. The study showed that one-third of Malaysian manufacturing SMEs have employed virtual R&D teams. Competitive advantage is now becoming available to SMEs through geographically open boundaries created by virtual teams. Existing practices within Malaysian manufacturing SMEs experts, who were involved with virtual teams, proved four-fold benefiting from the cross-functional virtual R&D teams, namely: 1-Reduced R&D cost and time, 2-More effective R&D, 3-Better output, 4-Increased coordination. Virtual R&D teams give better team outputs, reduce time-to-market, reduce travel costs and demonstrate the ability to tap selectively into centers of excellence. Additionally, virtual R&D teams enable the use of the best talents regardless of location, giving a greater degree of freedom to individuals, shorter development times, and quicker response to changing business environments as well as higher team effectiveness and coordination. Therefore, the decision for setting up virtual R&D teams in SMEs is not a choice, but a necessity.

This paper is probably the first to present an empirical research on virtual R&D teams, which is limited to Malaysian manufacturing SMEs. Future research is needed to investigate the four-fold benefits of virtual R&D teams by a larger sample from different

sectors. Although several studies have been carried out on the use of virtual R&D teams in large companies, applications within SMEs remain undocumented. Hence, future research should be focused on this gap and to search for a virtual collaborative system for SMEs which are dispersed geographically. Such a collaborative system should virtually link SMEs to enable the engaging members to focus on their specialized tasks as well as share their knowledge and experience (information resources). This will create agile manufacturing environments and enterprises.

Table 4. Clustered theme and cluster extracted from Table 3 (virtual team effectiveness).

No.	Cluster Level 1 /Theme	Cluster Level 2
1	Reduced R&D cost and time	Cost saving, Time saving Reduce time consumption Faster product release Reduced employees Reducing time of trips Reduce unnecessary time wastage
2	More effective R&D	Speeds up work progress Great convenience Facilitates decision-making Assists the current workload Improved performance Virtual team system/tool is effective Capable of attracting experts and knowledge workers
3	Better output	Enhances the flow of projects of a company Meets customer satisfaction Increases performance Improves work environment Expedites product outcome Demonstrates a positive annual trend
4	Increased coordination	Brings us closer Good connection between the entire assets of organization

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Issues: Summer 2011 - Volume 9 Issue 3

Virtual Teams and Management Challenges

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Introduction

Collaboration is becoming increasingly important in creating the knowledge that makes business more competitive. Virtual teams are growing in popularity [1] and many organizations have responded to their dynamic environments by introducing virtual teams. Additionally, the rapid development of new communication technologies such as the Internet has accelerated this trend so that today, most of the larger organization employs virtual teams to some degree [2]. A growing number of flexible and adaptable organizations have explored the virtual environment as one means of achieving increased responsiveness [3]. Howells et al. [4] state that the shift from serial to simultaneous and parallel working has become more commonplace. Based on conventional information technologies and Internet-based platforms virtual environments may be used to sustain companies' progress through virtual interaction and communication.

This paper provides comprehensive aspects of virtual teams based on authentic and reputed publications, after define virtual teams and its characteristics, addressing virtual environments and relationship with management and employee challenges. Finally conclude that virtual team cannot be successful unless the knowledge and information in the company are effectively captured, shared and internalized by the entity manager. Doing an extensive literature survey, further studies are recommended. Managerial implications on those issues are also discussed.

Virtual Teams Definition

This era is growing popularity for virtual team structures in organizations [1, 5]. Martins et al. [6] in a major review of the literature on virtual teams, conclude that 'with rare exceptions all organizational teams are virtual to some extent.' We have moved away from working with people who are in our visual proximity to working with people around the globe [7]. Although virtual teamwork is a current topic in the literature on global organizations, it has been problematic to define what 'virtual' means across multiple institutional contexts [8]. It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations [9]. Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of technology-supported working [10]. Virtual teams are comprised of members who are located in more than one physical location. This team trait has fostered extensive use of a variety of forms of computer-mediated communication that enable geographically dispersed members to coordinate their individual efforts and inputs [11]. From the perspective of Leenders et al.[12] virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization. Amongst the different definitions of the concept of a virtual team the following from is one of the most widely accepted: [13], "virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks". The degree of geographic dispersion within a virtual team can vary widely from having one member located in a different location than the rest of the team to having each member located in a different country [14].

Advantages and Pitfalls of Virtual Teams

The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. [10]. Virtual R&D teams which members do not work at the same time or place [15] often face tight schedules and a need to start quickly and perform instantly [16]. On the other hand, virtual teams reduce time-to-market [17]. Lead Time or Time to market has been generally admitted to be one of the most important keys for success in manufacturing companies [18]. Table 1 summarizes some of the main advantages and

Table **2** some of the main disadvantages associated with virtual teaming.

Table 1: Some of the main advantages associated with virtual teaming.

Advantages	References
Reducing relocation time and costs, reduced travel costs	[1, 19-29]
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker [30]]	[17, 18, 23, 24, 29, 31-38]
Able to tap selectively into center of excellence, using the best talent regardless of location	[1, 22, 24, 26, 39-43]

Greater productivity, shorter development times	[19, 35]
Greater degree of freedom to individuals involved with the development project	[44]
Higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another)	[1, 45, 46]
Producing better outcomes and attract better employees	[6, 20]
Provide organizations with unprecedented level of flexibility and responsiveness	[13, 24, 28, 31, 36, 47-49]
Respond quickly to changing business environments	[21, 35]
Sharing knowledge, experiences	[50, 51]
Enable organizations to respond faster to increased competition	[47, 52]
Better team outcomes (quality, productivity, and satisfaction)	[46, 53]
Most effective in making decisions	[54]
Higher team effectiveness and efficiency	[17, 55]
Self-assessed performance and high performance.	[8, 56]
Cultivating and managing creativity	[12]
Improve the detail and precision of design activities	[57]
Provide a vehicle for global collaboration and coordination of R&D-related activities	[58]

Table 2: Some of the main disadvantages associated with virtual teaming.

Disadvantages	**References**
lack of physical interaction	[1, 20, 23, 54]
everything to be reinforced in a much more structured, formal process	[59].
Challenges of project management are more related to the distance between team members than to their cultural or language differences	[60].
Challenges of determining the appropriate task technology fit	[61, 62]
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	[23, 56, 58]
Will create challenges and obstacles like technophobia (employees who are uncomfortable with computer and other telecommunications technologies)	[7]
Variety of practices (cultural and work process diversity) and employee mobility negatively impacted performance in virtual teams.	[8]
Team members need special training and encouragement	[63]

Virtual and Traditional Teams

Unlike a traditional team, a virtual team works across space, time and organizational boundaries with links strengthened by webs of communication technologies. However, many of the best practices for traditional teams are similar to those for virtual teams [21]. Virtual teams are significantly different from traditional teams. In the proverbial traditional team, the members work next to one another, while in virtual teams they work in different locations. In traditional teams the coordination of tasks is straightforward and performed by the members of the team together; in virtual teams, in contrast, tasks must be much more highly structured. Also, virtual teams rely on electronic communication, as opposed to face-to-face communication in traditional teams. Table 3 summarizes these distinctions [45]. Diversity in national background and culture is common in transnational and virtual teams [14].

Table 3: Virtual and traditional teams are usually viewed as opposites.

Fully Traditional Team	Fully Virtual Team
Team members all co-located.	Team members all in different locations.
Team members communicate face-to-face (i.e., synchronous and personal)	Team members communicate through asynchronous and impersonal means.
Team members coordinate team task together, in mutual adjustment.	The team task is so highly structured that coordination by team members is rarely necessary.

In particular, reliance on computer-mediated communication makes virtual teams unique from traditional ones [16]. The processes used by successful virtual teams will be different from those used in face-to-face collaborations (FFCs) [20]. In an innovation network resembling a "traditional" organization, the innovation process is more restricted by location and time. In other words, the innovation process mostly takes place within the framework of physical offices and working hours. In virtual organizations, individuals' work is not restricted by time and place, and communication is strongly facilitated by IT. Such a product development environment allows a greater degree of freedom to individuals involved with the development project [44]. Hence multinational companies (MNC) are more likely to become tightly integrated into global R&D network than smaller unit [64]. Distributed teams can carry out critical tasks with appropriate decision support technologies [65].

Physical Versus Virtual

Pawar and Sharifi [66] study of virtual versus collocated team success and classified physical teams versus virtual teams in six categories. Table 4 summarizes these differences.

Table 4: Classifying physical teams versus virtual teams

Activity	Physical teams nature	Virtual teams nature
Nature of interaction	opportunity to share work and non-work related information	the extent of informal exchange of information is minimal
Utilization of resources	Increases the opportunity for allocation and sharing of resources	each collaborating body will have to have access to similar technical and non-technical infrastructure
Control and accountability (over and within the project):	the project manager provides the Context for ongoing monitoring of activities and events and thus enhances their ability to respond to requirements.	The collaborating bodies were accountable to the task leaders and the project coordinator who had limited authority to enforce any penalties for failure to achieve their tasks
Working environment	they encountered constraints accessing information and interacting with others outside the collocated team within the company	Sometimes not able to share ideas or dilemmas with other partners.
Cultural and educational background	members of the team are likely to have similar and complementary cultural and educational background	the team members varied in their education, culture, language, time orientation and expertise

Lurey and Raisinghani [59] base on virtual teams survey in 12 separate virtual teams from eight different sponsor companies in the high technology found that, organizations choosing to implement virtual teams should focus much of their efforts in the same direction they would if they were implementing traditional, co-located teams.

Management Challenges

More and more companies are faced with the necessity to get the knowledge and expertise they require in different projects from different domains and areas [67], therefore, people from different companies often need to work together to bring the entire knowledge and experience that are needed for the success of a new product, process or service. Virtual teams represent a large pool of know-how which seems to be a promising source of companies' growth. At present, except for open source software, little is known about how to utilize this know-how [68]. Hence manager of enterprises should establish a connection between different departments and companies through virtual team stand on information technology. Based on a time scale, Figure 1 presents significant innovations that have had an impact on operation management (OM) [69]. Over the past decade, the developments in communications, primarily based on ICTs, have created a new platform for OM to connect enterprises and customers in a seamless information network.

The continuous rapid growth in project information volume as the project progresses makes it increasingly difficult to find, organize, access and maintain the information required by project users [70]. This particular problem can be highlighted in two cases document management on site and Information management at the facilities management stage [70]. Dealing with multiple, cross functional people and teams highlighted managing challenge. Manager of virtual team should overcome the managing conflict [49, 62, 71-74] , cultural and functional diversity in virtual teams [16, 23, 42, 43, 56, 58, 75-78] and mistrust among the team members [1, 50, 79-81].

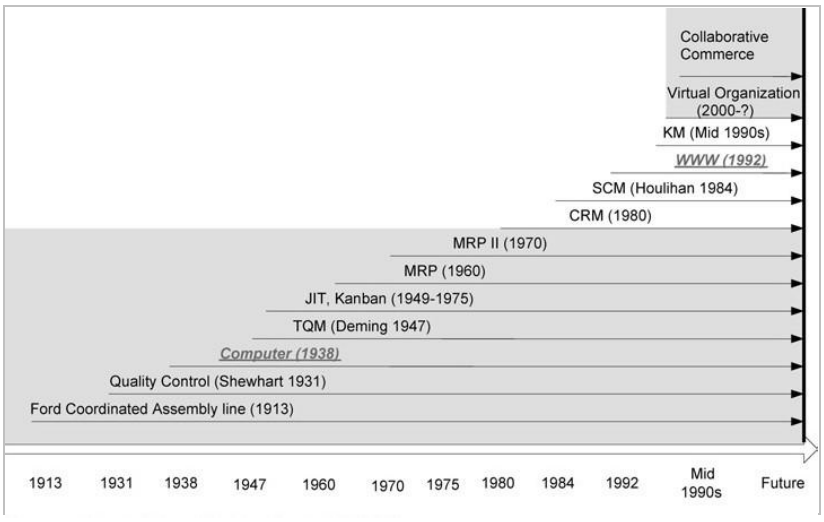

Figure 1 Innovation in operations management (Source: Bayraktar et al.(2007))

Conclusions

Since cross functional and virtual work teams are dealing with complex problems, it makes sense that cross functional virtual management teams are needed to support them. Problems from one team can pollinate widely on to other virtual teams. Management

must define the escalation path to resolve virtual, cross functional issues. While reviewing the previous study refer to Table 1 and

Table **2**, it's believed that the advantages of working on the basis of virtual teams far outweigh the disadvantages and firms cannot be successful unless the knowledge and information in the company are effectively captured, shared and internalized by the entities virtual team members.

This paper has provided an extensive review of literature and related resources covering the theme of virtual teams and management issue. Clearly there is a considerable scope for extending this study to specify filed such as small and medium enterprises (SMEs) and relationship with virtual team. Further research has to be done on this topic to fully understand the influence of virtual team on company practically. There is considerable literature on distributed and virtual teams. The coverage includes management challenges, technology enablers and organizational and multi-cultural challenges. However, limited work has been directed towards exploring and analyzing the existing inter-relation. Therefore future research shall be aimed at shifting away from investigating virtual teams separately to the formation and development of a collaborative system which can support a dispersed team effectively. Keeping virtual teams in company growth processes, operating innovatively, effectively and efficiently is of a high importance, but the issue has poorly been addressed simultaneously in the previous studies.

Managers of company should invest less in tangible assets, but more in virtual team to generate knowledge, and increase employees' creativity to stimulate incremental innovations in already existing information technology that will directly generate their future competitive advantage.

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ISSN: 1533-7812

academic LEADERSHIP LIVE
THE ONLINE JOURNAL
Issues: Fall 2011 - Volume 9 Issue 4

Virtual R&D Teams: A potential growth of education-industry collaboration

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Introduction

With the advent of the global economy and high-speed Internet, online collaboration is fast becoming the norm in education and industry [1]. Information technology (IT) creates many new inter-relationships among businesses, expands the scope of industries in which a company must compete to achieve tcompetitive advantage. Information systems and technology allow companies to coordinate their activities in distant geographic locations [2]. IT is providing the infrastructure necessary to support the development of new collaboration forms among industry and education. Virtual research and development (R&D) teams represent one such relational form, one that could revolutionize the workplace and provide organizations with unprecedented levels of flexibility and responsiveness [3-4]. Virtual teams give many advantages to organizations, including increased knowledge sharing [5] and improve organizational performance [6]. Virtual teams have altered the expectations and boundaries of knowledge worker's interactions. Many R&D organizations and teams currently use a specialized knowledge portal for research collaboration and knowledge management [7]. Hence, the move towards a virtual world is becoming ever more relevant to industry and education as organizations outsource activities across national geographic boundaries [8].

The purpose of this study is to extend the research finding of virtual R&D teams in small and medium-sized enterprises to industry-education collaboration. The further outline of this paper is as first, discuss the different aspects of virtual teams and its relationships with SMEs, and then briefly explore the research methodology. Following, elaborate on the empirical findings and finally, analysis the data and conclude the paper.

Aspects of Virtual Teams

Definition of Virtual Team

Gassmann and Zedtwitz [9] defined "virtual team as a group of people and sub-teams which interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Different authors have identified diverse definition [10]. Reference [11] developed one of the most comprehensive and widely accepted definitions of virtual teams: "virtual team is the small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks."

Benefits and Pitfalls of Virtual Teams

The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams [11]. Virtual team may allow people to collaborate with more productivity at a distance [12]. Virtual teams reduce time-to-market [13]. Lead time or time to market has been generally admitted to be one of the most important keys for success in manufacturing companies [14]. A potential advantage of virtual teams is their ability to digitally or electronically unite experts in highly specialized fields working at great distances from each other [15]. Virtual teams are enlightening and managing creativity [16] and useful for projects that require cross-functional or cross boundary skilled inputs [17].

As a drawback, virtual teams are particularly weak at mistrust, communication and power struggles [15]. Cultural and functional diversity in virtual teams leads to differences in the members thought processes [18]. Virtual teams will not totally replace conventional teams. Although virtual teams are and will continue to be an important and necessary type of work arrangement, they are not appropriate for all circumstances [19]. Hence, the complexity of management and coordination to choose the best collaboration tools will increases.

SMEs and Virtual Teams

SMEs need to focus on core competences for efficiency matters; they need to cooperate with external partners such as an educational institute to compensate for other competences and resources. Reference [20] found that managers of SMEs should invest less in tangible assets, but more in those areas that will directly generate their future competitive advantage (e.g., in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in already existing technologies). The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtually invention [21]. While, it is widely known that many big corporations have already invested in the information technology (IT) as they have come to realize the advantages and the competitive edge they will gain from IT. It is believed that SMEs, without investing heavily in total solution systems, can still benefit from the available information technology [22]. Virtuality has been presented as one solution for SMEs aiming to increase their competitiveness [23]. The SMEs are one of the sectors that have a strong potential to benefit from advances of virtual teams and the adaptation of new collaboration modes [24].

Methodology

Data for this research is gathered from the desk study and survey in Malaysian and Iranian small and medium-sized enterprises (SMEs). A web based questionnaires is designed and distributed between manufacturing SMEs. The rapid expansion of Internet users has given web-based surveys the potential to become a powerful tool in survey research [25]. Reference [26] findings encourage social researchers to use web-based questionnaires with confidence and the data produced by web-based questionnaires is equivalent to that produced by paper-based questionnaires.

The main sampling target was managing director, R&D manager, new product development manager, project and design manager and appropriate people who were most familiar with the R&D concern in the firm. A Likert scale from 1 to 5 was used. This set up gave respondents a series of attitude dimensions. For each dimension, the respondent was asked whether, and how strongly, they agree or disagree to each dimension using a point rating scale. Based on collected data some interpretations of the current situation of SMEs to employ virtual R&D teams are developed. Statistical methods and analysis are carried out to examine the SMEs readiness for education-industry collaboration.

Data Collection and Analysis

The empirical data has been collected through on-line questionnaires with manufacturing SMEs in Malaysia and Iran. Out of the 3625 companies targeted, 947 responded, 210 completed the questionnaire and the rest were partially-respondents. The response rate was satisfactory since accessing the managers is usually difficult. Table 1 summarized online survey data collection. Although the on-line questionnaire sent to the targeted SMEs in the both countries, only 91 firms were met the criteria of SMEs definition in this research so the rest of responded deducted from analysis.

Table 1 Summarized on-line survey data collection

Total of emails sent to companies	3625
Total responses	947
Total responses / sent (%)	26.1
Total completed	210
Total completed / sent (%)	5.8
Response rate (%)	22.2

A cross-tabulation descriptive statistics employed to find the frequency and relationship between the country and virtual team as illustrate in Table 2. The result shows that in the sample 53.8% of targeted SMEs employed virtual teams in R&D and Iranian SMEs employed virtual teams more than two times of Malaysian SMEs 71.4 and 33.3 percent respectively.

The mean scores for frequency of use to exchange business shows that E-mail is the most frequently used tool for all teams in Malaysia and Iran. Personal telephone call is second most frequently used tool in selected countries. Malaysian firms used more face to face interaction than Iranian ones. On the other hand, team base communication technologies such as shared database, group telephone conference, electronic whiteboard and video conference were not often used.

The last sections of the questionnaire developed to identify the requirements of the SMEs in determining the appropriate collaborative tools. The Likert scale ranged from "1" for not important to "5" for extremely important, with "4" as the neutral point. The Likert mean was 3.31 (Figure 1) on the 5-point scale for demand of "online training and e-learning". The score is clearly in the direction that, SMEs needs to the education-industry collaboration. Hence, sample SMEs in Malaysia and Iran are enthusiastic over use virtual teams for industry-education collaboration. This empirical study across countries shows a substantial and increasing return to virtual teams in SMEs. New technologies open up opportunities for small firms to expand their collaboration beyond firms' borders.

Table 2 Cross-tabulation between country and virtual teams

		With Virtual Teams		Total
		Yes	NO	
Iran	Count	35	14	49
	% within Country	71.4%	28.6%	100.0%
Malaysia	Count	14	28	42
	% within Country	33.3%	66.7%	100.0%
Total	Count	49	42	91
	% of Total	53.8%	46.2%	100.0%

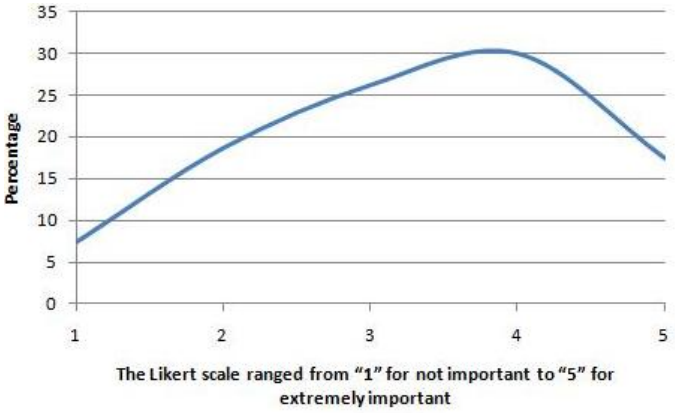

Figure 1 The 5-point scale for demand of "online training and e-learning"

Conclusion

Nowadays, distance between team members or differences in time zones, are not barriers to industry and education collaborations. Using a virtual R&D team's context as a collaborating environment provides industry management with opportunities to acquire some of the technical skills required for the professional workplace. The paper concludes that virtual R&D teams and industry-education collaboration have much more benefits than disadvantages. In fact, selecting the appropriate sets of communication tools are challenging for the virtual team's managers.

Above 46% of SMEs in selected countries are still avoiding to use virtual teams. Today's combative environments dictate a new model of communication as a basic requirement. The SMEs in Iran and Malaysia have to restructure their approach to employ virtual teams. Many SMEs have limited recourses, and it is well-known for their dynamic behavior in contrast the difficulty of diverting skilled personnel from day-by-day activities, to undertake process re-engineering and R&D. Therefore, applying virtual R&D teams in SMEs is a foundation of high growth industry-education collaboration.

Future research would now seem to be essential for developing a comprehensive study, combining survey with case studies in various sizes of companies and types of activities (e.g. research and development and new product development). Such a study needs to investigate a larger sample of virtual teams from different sectors. In a bigger group, it is possible to compare the results between countries more precisely.

Acknowledgment

This study is carried out as a part of funded research by a grant from the University of Malaya (grant No. PS404/2009C), the authors acknowledge this support.

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ISSN: 1533-7812

American J. of Engineering and Applied Sciences 5 (1): 9-14, 2012
ISSN 1941-7020

Technology Use in the Virtual R&D Teams

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Abstract: Problem statement: Although, literature proves the importance of the technology role in the effectiveness of virtual Research and Development (R&D) teams for new product development. However, the factors that make technology construct in a virtual R&D team are still ambiguous. The manager of virtual R&D teams for new product development does not know which type of technology should be used. **Approach:** To address the gap and answer the question, the study presents a set of factors that make a technology construct. The proposed construct modified by finding of the field survey (N = 240). We empirically examine the relationship between construct and its factors by employing the Structural Equation Modeling (SEM). A measurement model built base on the 19 preliminary factors that extracted from literature review. The result shows 10 factors out of 19 factors maintaining to make technology construct. **Results:** These 10 technology factors can be grouped into two constructs namely Web base communication and Web base data sharing. The findings can help new product development managers of enterprises to concentrate in the main factors for leading an effective virtual R&D team. In addition, it provides a guideline for software developers as well. **Conclusion:** The second and third generation technologies are now more suitable for developing new products through virtual R&D teams.

Key words: Collaboration teams, questionnaires performance, cross-functional teams, product development, structural equation modeling, measurement model, literature review

INTRODUCTION

Virtual teams are defined as "small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, mainly with electronic information and communication technologies to carry out one or more organization tasks" (Ebrahim *et al*., 2009b). Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities (Ebrahim *et al*., 2011). The members of a virtual R&D team use different degrees of communication technology to complete the research without space, time and organizational boundaries (Nader *et al*., 2010a, Husain and Yong, 2009). "We are becoming more virtual all the time!" is heard in many global corporations today (Chudoba *et al*., 2005). On the other hand, New Product Development (NPD) is widely recognized as a key to corporate prosperity (Lam *et al*., 2007). The specialized skills and talents needed for developing new products often remain locally in pockets of excellence around the company or even around the world. Therefore, enterprises have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer *et al*., 2005). As a result, enterprises are finding that internal development of all technology needed for new products and processes are difficult or impossible. They must increasingly receive technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make serious headway due to developments in technology-virtuality in NPD which is now technically possible (Leenders *et al*., 2003). As product development becomes the more complex, supply chain, also have to collaborate more closely than in the past. These kinds of collaborations almost always involve individuals from different locations, so virtual team working supported by Information Technology (IT), offers notable potential benefits (Anderson *et al*., 2007). Although the use of the internet in NPD has received notable attention in the literature, little is written about collaborative tool and effective virtual teams for NPD (Ebrahim *et al*., 2009a). In addition, literature shows the

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factors that make technology construct in a virtual R&D team are still ambiguous. I this study we try to fill the gap in the literature.

This study is structured as follows. First, base on prior research we extract the 19 factors of technology construct in the virtual R&D teams. Next, Structural Equation Modeling (SEM) is used as the analytical tool for testing the estimating and testing the technology construct measurement models. Then adjust the preliminary technology construct the model by fitting the model according to the SEM fitness indices and made a final measurement model. The study infers with a discussion and future guidelines.

Literature review: Virtual teams use digital communications, video and audio links, electronic whiteboards, e-mail, instant messaging, websites, chat rooms, as substitutes for physical collocation of the team members (Baskerville and Nandhakumar, 2007, Pauleen and Yoong, 2001). Simple transmission of information from point A to point B is not enough; the virtual environment presents significant challenges to effective communication (Walvoord *et al*., 2008). Being equipped with even the most advanced technologies are not enough to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be present for a team to succeed in the virtual world (Lurey and Raisinghani, 2001). Virtual teams are technology-mediated groups of people from different discipline that work on common tasks (Dekker *et al*., 2008) so the way the technology is implemented seems to make the virtual teams outcome more or less likely (Anderson *et al*., 2007). Virtual R&D team instructor should choose the suitable technology based on the purpose of the team (Ebrahim *et al*., 2009c).

Factors that make technology construct in a virtual R&D team are still ambiguous. We extracted 19-importance factors related to the technology construct, base on a comprehensive review on technology view in the virtual R&D team working. Table 1 summarized the factors and their supported references. E-mails and conference calls are generally known as first generation technologies while online discussion boards, power point presentations, video tools and online meeting tools are second-generation technologies. Third generation technology refers typically to web-enabled shared workspaces with the intranet or internet (Lee-Kelley and Sankey, 2008).

Research method: To build a measurement model of technology construct in virtual R&D teams for new product development, we conducted a web-based survey mainly in Malaysian and Iranian manufacturing enterprises, in a random sample of small and medium enterprises. Web-based survey method is selected because; it is a cost-effective and quick result to get feedback from the belief of the respondent. A Likert scale from one to five was used. This set up gave respondents a series of attitude dimensions. For each factor, the respondent was asked whether, the factor is not important or extremely important by using a Likert scale rating. The questionnaire was emailed to the managing director, R&D manager, the new product development manager, project and design manager and suitable people who were most familiar with the R&D activities in the firm. The rapid expansion of Internet users has given web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002, Nader *et al*., 2010b).

Table 1: Summary of the factors related to the technology construct in the virtual teams

Factor name	Factor descriptions	References
Tech1	Use internet and electronic mail	(Redoli *et al*., 2008, Pauleen and Yoong, 2001, Lee-Kelley and Sankey, 2008, Thissen *et al*., 2007)
Tech2	Online meeting on need basis	(Chen *et al*., 2007; Lee-Kelley and Sankey, 2008; Pena-Mora *et al*., 2000; Thissen *et al*., 2007)
Tech3	Web conferencing	(Coleman and Levine, 2007; Thissen *et al*., 2007, Zemliansky and Amant, 2008; Ebrahim *et al*., 2009c)
Tech4	Seminar on the Web	(Zemliansky and Amant, 2008)
Tech5	Shared work spaces	(Lee-Kelley and Sankey, 2008)
Tech6	Video conferencing	(Chen *et al*., 2007; Zemliansky and Amant, 2008)
Tech7	Audio conferencing	(Chen *et al*., 2007; Lee-Kelley and Sankey, 2008; Zemliansky
Tech8	Online presentations	(Lee-Kelley and Sankey, 2008) and Amant, 2008)
Tech9	Share documents (off-line)	(Coleman and Levine, 2007; Ebrahim *et al*., 2009c)
Tech10	Share what's on your computer desktop with people in other locations (Remote access and control)	(Thissen *et al*., 2007; Ale *et al*., 2009)
Tech11	Do not install engineering software (get service through web browser)	(Coleman and Levine, 2007; Kotelnikov, 2007, Vasileva, 2009)
Tech12	Access service from any computer (in Network)	(Thissen *et al*., 2007; Vasileva, 2009)
Tech13	Standard phone service and hybrid services	(Thissen *et al*., 2007; Ebrahim *et al*., 2009c)
Tech14	Access shared files anytime, from any computer	(Lee-Kelley and Sankey, 2008)
Tech15	Web database	(Coleman and Levine, 2007; Zemliansky and Amant, 2008; Ebrahim *et al*., 2009c)
Tech16	Provide instant collaboration	(Coleman and Levine, 2007; Thissen *et al*., 2007)
Tech17	Software as a service (canceling the need to install and run the application on the own computer)	(Coleman and Levine, 2007; Thissen *et al*., 2007)
Tech18	Virtual research center for product development	(Zemliansky and Amant, 2008)
Tech19	Can be integrated/compatible with the other tools and systems	(Coleman and Levine, 2007; Kotelnikov, 2007)

Invitation e-mails were sent to each respondent, reaching 972 valid email accounts, with reminders following every two weeks up to three months. 240 enterprises completed the questionnaire, for an overall response rate of 24.7% Table 2.

RESULTS

Anderson and Gerbing (1988) suggested using Confirmatory Factor Analysis (CFA) for scale development because it affords stricter interpretation of unidimensionality than what is provided by more traditional approaches, such as coefficient alpha, item-total correlations and exploratory factor analysis. The evidence that the measures were one-dimensional, where a set of indicators (factors) shares only a single underlying construct, was assessed using CFA (Anderson and Gerbing, 1988). After data collection, the measures purification procedures should be used to assess their reliability, unidimensionality, discriminate validity and convergent validity (Anderson and Gerbing, 1988).

For reliability analysis, Cronbach's Alpha (Cronbach, 1951) was employed to each factor. As shown in Table 3, all the items with Cronbach's α greater than threshold 0.6 were included in the analysis and the rest omitted from analysis. So, the factors Tech1, Tech10, Tech11 and Tech13 freed from further analysis. In general, the reliability of the questionnaire's instruments displayed a good reliability across samples.

Structural Equation Modeling (SEM) using AMOS 18 was employed for validation of the measurement model. This statistical analysis are estimated simultaneously for both the measurement and structural models (Dibrell *et al*., 2008). To ensure the factors make a right construct, the measurement model examined for model fit. Given this, the model assessed for the convergent and discriminant validity.

Table 2: Summarized online survey data collection

Numbers of emails sent enterprises	3625
Total responses (Click the online web page)	972.0
Total responses / received questionnaire (%)	26.8
Total completed	240.0
Total completed / received questionnaire (%)	24.7

Convergent validity was established using a calculation of the factor loading, Average Variance Extracted (AVE) and Composite Reliability (CR). The factors that have standardized loadings exceeded 0.50, were maintained (Dibrell *et al*., 2008). The initial measurement model was consisting of 19 factors (Tech1 to Tech19). After revising the measurement model by deleting Tech1, Tech10, Tech11 and Tech13, the AVE and CR were calculated. AVE larger than 0.5 is the threshold (McNamara *et al*., 2008). CR is calculated by squaring the sum of loadings, then dividing it by the sum of squared loadings, plus the sum of the measurement error (Lin *et al*., 2008). CR should be greater than 0.6 (Huang, 2009). The measurement model had acceptable convergent validity since the calculated CR and AVE were 0.930 and 0.613 respectively.

For discriminant validity, we performed AMOS software using Maximum Likelihood method (ML). The fitting indices checked with their respective acceptance values Table 4. We run the AMOS for the model Ver1 (technology construct with 15 factors) and found a nonsignificant chi-square per degrees of freedom (CMIN/DF = 7.232). Most of the rest of fit indices was not in the acceptable range.

Table 3: Summary of the final measures and reliabilities

Factor name	Corrected item-total correlation	Cronbach's alpha if Item deleted
Tech1	0.525	0.943
Tech2	0.755	0.939
Tech3	0.777	0.939
Tech4	0.717	0.940
Tech5	0.759	0.939
Tech6	0.722	0.940
Tech7	0.731	0.939
Tech8	0.780	0.939
Tech9	0.610	0.942
Tech10	0.576	0.942
Tech11	0.571	0.943
Tech12	0.686	0.940
Tech13	0.519	0.943
Tech14	0.624	0.941
Tech15	0.696	0.940
Tech16	0.642	0.941
Tech17	0.678	0.940
Tech18	0.649	0.941
Tech19	0.615	0.942

Table 4: Fitting indices (adopted from (Byrne, 2001)

Fit Indices	Desired range
χ^2 /degrees of freedom (CMIN/DF)	≤ 2.00
IFI (Incremental Fit Index)	≥ 0.90
Comparative Fit Index (CFI)	Coefficient values range from zero to 1.00, with values close to 0.95 showing superior fit
RMSEA (Root Mean Squire Error of Approximation)	values less than .05 show good fit and values as high as .08 represent reasonable fit, from 0.08-0.10 show mediocre fit and those greater than 0.10 show poor fit
Root mean square residual (RMR)	≤ 0.08
Goodness-of-Fit Index (GFI)	≥ 0.90
Normed Fit Index (NFI)	Coefficient values range from zero to 1.00, with values close to 0.95 showing superior fit
Relative Fit Index (RFI)	Coefficient values range from zero to 1.00, with values close to 0.95 showing superior fit
Tucker-Lewis Index (TLI)	Values ranging from zero to 1.00, with values close to 0.95 (for large samples) being indicative of good fit

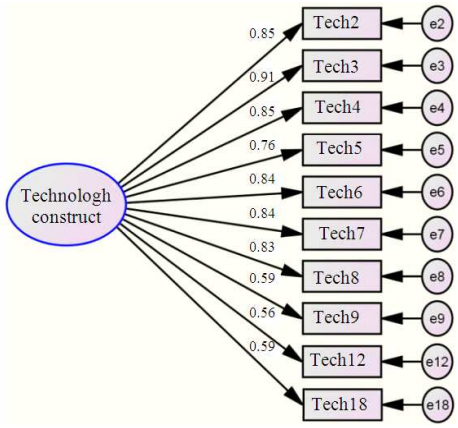

Fig. 1: Measurement model Ver2

Thus, refer to the AMOS Modification Indices (MI) some of the factors that had the lowest factor loading or the same effect of remaining factor, were deleted. With this modification, the measurement model Ver2 had a significant chi-square per degrees of freedom (CMIN/DF = 4.767); other fit indices, RMSEA, RMR and GFI also were in the acceptable range. Therefore, the best fitting model was the measurement model Ver2 Fig. 1 and it used for further analysis.

DISCUSSION

The final measurement developed made base on the measurement model ver2 by classifying the factors in two groups according to their relevant factor loading with the threshold 0.83. The proper name for each group can be web base; communications and data sharing respectively. As displayed in Fig. 2 each factor loading was above 0.62 and significant. Overall, the final measurement model produced good fit indices (CMIN/DF = 2.889, RMR = .04, GFI = 0.929, RFI = 0.929, NFI = 0.949, TLI = 0.952, CFI = 0.966 IFI = 0.964, RMSEA = 0.089).

While fitting the technology construct the measurement model the factors Tech14 (access shared files anytime, from any computer), Tech15 (web database), Tech16 (provide instant collaboration), Tech17 (software as a service (eliminating the need to install and run the application on the own computer)) and Tech19 (can be integrated/compatible with the other tools and systems) were dropped. Modification indices (MI) base on regression weights shows Tech17, Tech 18 and Tech19 are highly correlated, so one representative (Tech18) from this group is enough. Tech14 to Tech16 are strongly correlated with Tech12, so the remaining factor represents the deleted ones.

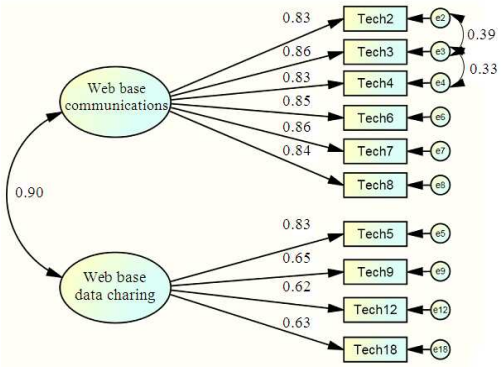

Fig. 2: Final measurement model

The results of the final measurement model of technology construct in virtual R&D team for developing a new product, shows the share of two main contrasts, which are strongly correlated to each other:

- Web base communications consists of online meeting on needed basis, web conferencing, seminar on the web, video conferencing, audio conferencing and online presentations
- Web base data sharing consists of shared work spaces, share documents (off-line), access service from any computer (in network) and virtual research center for product development

According to Lee-Kelley and Sankey (2008) these two constructs belong to the second and third generation of technology. Equip virtual R&D team members with the suitable technology make the teams more effective. Therefore, the manager of NPD should provide the facilities and infrastructures for the virtual R&D teams to achieve the higher level of team effectiveness.

CONCLUSION

Research so far has explored the 19 factors for working together virtually; however, us still less know about the factors which has main contributions in the technology construct of the virtual R&D teams for New product development. The findings of this study extend the literatures and help to build a foundation for further understanding of the technology elements in the virtual R&D teams for new product development. The measurement model shows ten factors that make the technology constructs. These ten factors can be sorted by their factor loading which are reflecting the factor weight. Therefore, the software developer or the managers of the NPD are able to provide a better

platform for virtual team working by concentrating on the main factors. The second and third generation of technology (refer to definition of Lee-Kelley and Sankey (2008) is now more suitable for developing a new product through virtual R&D teams.

Future research is needed to examine the effects of each factor to perform the virtual R&D teams while the others constructs of virtual teams such as process and people are present. A new SEM is needed to demonstrative the relationship between factors-constructs and constructs-constructs which is not investigated yet in the literature.

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Advanced Materials Research Vols. 433-440 (2012) pp 1653-1659
© (2012) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/AMR.433-440.1653

Virtual Collaborative R&D Teams in Malaysia Manufacturing SMEs

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Keywords: Small and medium enterprises, Collaborative tools, Questionnaires, Virtual teams.

Abstract. This paper presents the results of empirical research conducted during March to September 2009. The study focused on the influence of virtual research and development (R&D) teams within Malaysian manufacturing small and medium sized enterprises (SMEs). The specific objective of the study is better understanding of the application of collaborative technologies in business, to find the effective factors to assist SMEs to remain competitive in the future. The paper stresses to find an answer for a question "Is there any relationship between company size, Internet connection facility and virtuality?". The survey data shows SMEs are now technologically capable of performing the virtual collaborative team, but the infrastructure usage is less. SMEs now have the necessary technology to begin the implementation process of collaboration tools to reduce research and development (R&D) time, costs and increase productivity. So, the manager of R&D should take the potentials of virtual teams into account.

Introduction

Collaboration in research and development (R&D) is becoming increasingly important in creating the knowledge that makes research and business more competitive [1]. The internet, incorporating computers and multimedia, has provided tremendous potential for remote integration and collaboration in business and manufacturing applications [2]. Web service technology also provides a unique way to application-to-application interaction over the internet [3]. Currently, many R&D organizations and teams use a specialized knowledge portal for research collaboration and knowledge management [4]. A web-based virtual collaborative team is enabling authorized users in geographically different locations to have access to the company's product data such as product drawing files stored at designated servers and carry out product design work simultaneously and collaboratively on any operating systems [5]. Despite computers' widespread use for personal applications, very few SMEs use this new phenomenon [6]. On the other hand, small and medium-sized enterprises (SMEs) which are a major part of the industrial economies [7] needs to reduce R&D time and costs in order to compete in the competitive market. Gassmann and Keupp [8] found that managers of SMEs should invest less in tangible assets, but more in those areas that will directly create their future competitive advantage (e.g., in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in existing technologies). One very important trend to enable new knowledge creation and transfer in and to SME's is developing virtual collaborative environments and networks to increase their innovation abilities as a single unit but also the capabilities of the network as a whole [9]. Virtuality has been presented as one solution for SMEs aiming to increase their competitiveness [10, 11]. Virtual teams reduce time-to-market [12, 13]. Lead Time or Time to market has been generally admitted to being one of the most important keys for success in manufacturing companies [14].

In line with moving trend to virtual collaborative teams in SMEs, this paper based on the survey results explore the relationship between the number of SMEs employee and the Net connection facility with virtuality. While, virtuality brings couples of advantages to SMEs, the question is raised "Why SMEs do not use virtual collaborative teams?". Based on literature and survey finding future study and suggestions are advanced.

SMEs DEFINITION AND IMPORTANCE

There are many accepted definitions of SMEs, and the classifications vary from industry to industry and from country to the country [15]. Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises [16]. The case studies employed the definition of Malaysian manufacturer sector SMEs according to Table I.

TABLE I. DEFINITION OF MALAYSIAN MANUFACTURING SMES [ADOPTED FROM (ALE EBRAHIM ET AL., 2009A)]

Category of enterprise	Employee numbers	Turnover
Small	Between 5 to 50 employees	Between RM 250,000 (~80,000 USD) & less than RM 10 million (~3.2 million USD)
Medium	Between 51 to 150 employees	Between RM 10 million (~3.2 million USD)& RM 25 million (~8 million USD)

Economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance [17]. In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles [18, 19]. SMEs also serve as the key engine behind equalizing income disparity among workers [20].

TABLE II. SUMMARIZED ONLINE SURVEY DATA COLLECTION

Numbers of emails sent to Malaysian Firms	2068
Total Responses (Click the online web page)	356
Total Responses / Received questionnaire (%)	17.2
Total Completed	74
Total Completed / Received questionnaire (%)	20.8

R&D DISTRIBUTED TEAM AND SMEs

SMEs need appropriate and up-to-date knowledge in order to compete and there is a strong need to create, share and disseminate knowledge within SME's [21]. Especially, in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development [22]. The key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing processes [23]. Dickson and Hadjimanolis [24] examined innovation and networking among small manufacturing companies. They found some tentative evidence that companies operating in terms of "the local strategic network" are more innovative than those operating in terms of "the local self-sufficiency". In the beginning of R&D activities SMEs always face capital shortage and need technological assistance. Most firms today do not operate alone; they are networked vertically with

many value-chain partners [25]. R&D activities are now dependent to different location drivers [26]. Most SMEs are heavily reliant on external sources, including customers and suppliers, for the generation of new knowledge [27]. SMEs of all sizes must reach out into their external environment for necessary resources [28]. In the present era of globalization, it is obvious that the survival of the SMEs will be determined first and foremost by their ability to manufacture and supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources [29]. In order to face this challenge, SMEs can reinforce knowledge to create synergies that allow firms to overcome difficulties and succeed. This may lead to new relationships between different agents to overcome scarcity and/or difficulties in gaining access to resources [30]. The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtual invention [25]. Web resource services can help the enterprises to get external service resources and implement collaborative design and manufacturing [31]. Sharma and Bhagwat [29] study results reveal that IT in SMEs is still in a backseat, although the use of computers is continuously increasing in their operations.

METHOD & DATA COLLECTIONS

An online survey was conducted in the spring and summer of 2009 to identify the relationship between the number of employees, Internet connection and virtual teaming, among the Malaysian manufacturing SMEs. The on line questionnaire was distributed through the e-mail to Malaysian manufacturing SMEs. Two thousand and sixty eight email addresses collected from Malaysian SME Business Directory [32] and questionnaires were sent to manufacturing SMEs. The online system received replies from 356 entities were received the email and clicked the link, within the desired timeframe. Participants were directed to a website, and the survey was completed on-line. The rapid expansion of Internet users has given web-based surveys the potential to become a powerful tool in survey research [33]. Denscombe [34] findings encourage social researchers to use web-based questionnaires with confidence and the data produced by web-based questionnaires is equivalent to that produced by paper-based questionnaires. Other authors stressed the data provided by Internet methods are of at least as good quality as those provided by traditional paper-and-pencil methods [35, 36]. The survey was first tested with 12 expert people, then adjusted and distributed.

Finally, a questionnaire was distributed to 356 Malaysian manufacturing SMEs. The main target group regards the organization's size and field of industry was, managing director, R&D manager, new product development manager, project and design manager and right people who were most familiar with the R&D issue in the organizations. 74 usable questionnaires were received, representing a 20.8 percent return rate. The response rate was satisfactory since accessing the managers is usually difficult. Table II summarized online survey data collection. 42 SMEs were met the criteria of this research so the rest of responded took away from analysis. Descriptive statistics were used to analyze the responses. Table III shows the frequency of using virtual teams among the sample Malaysian SMEs.

TABLE III. CROSS-TABULATION BETWEEN COUNTRY AND VIRTUAL TEAM

	Using Virtual Team		**Total**
	Yes	***NO***	
Count	14	28	42
%	33.3%	66.7%	100.0%

TABLE IV. CROSS-TABULATION BETWEEN VIRTUAL TEAM, NUMBER OF EMPLOYEES AND THE TYPE OF INTERNET CONNECTIONS

With Virtual Teams	Internet connection	Number of Employees Count (%)						Total
		10<	11-20	21-30	31-50	51-100	101-150	
Yes	*Broadband Network*	7	3	1				11
	DSL (Digital Subscriber Line)	2	0	0				2
	Direct Satellite Connection	0	1	0				1
Total		9 (64.3)	4 (28.6)	1 (7.1)				14 (100)
No	*Do not have internet connection*	0	0	0	1	0	0	1
	Dial Up	1	1	0	0	0	0	2
	ISDN	0	1	0	0	0	0	1
	Broadband Network	8	6	1	3	2	1	21
	DSL (Digital Subscriber Line)	0	1	0	0	1	0	2
	Direct Satellite Connection	1	0	0	0	0	0	1
Total		10 (35.7)	9 (32.1)	1 (3.6)	4 (14.3)	3 (10.7)	1 (3.6)	28 (100)

SURVEY RESULTS AND DISCUSSION

From the data presented in Table III, we see that although, virtual teams' application in manufacturing SMEs is still in infancy but virtual teaming is becoming accepted in Malaysian manufacturing SMEs. One out of three companies uses virtual teams. A cross-tabulation descriptive statistics employed to find the frequency and relationship between the virtuality, number of employees and the type of internet connections, as illustrate in Table IV. The result shows that small SMEs employed virtual collaborative teams but medium sized SMEs in the sample did not use virtual teams, although they have sufficient internet connection facilities.

Correlation Analysis.

Due to the lack of normality of collected data the Spearman non-parametric statistical correlations for ordinal data were, employed. Table V shows, the significant correlation coefficient between virtuality and number of employees ($p = 0.035$ and $r = 0.327$). The result shows that virtuality and number of employees (0.327) has the strongest relationship among virtuality, Internet connections and number of employees. There is not significant correlation between Internet connections, number of employees and virtuality.

The research findings indicate that both SMEs with employing virtual teams and not, equally has access to the internet connection's facilities. No correlation was found between the number of Employees in SMEs and Internet connections in the Malaysian manufacturing sector. Spearman's rho correlation coefficient was -0.090.

TABLE V. CORRELATIONS BETWEEN VIRTUALITY, INTERNET CONNECTIONS AND NUMBER OF EMPLOYEES

		No. of Employees	Virtuality	Internet connections
No. of Employees	***Correlation Coefficient***	1.000	0.327*	-0.090
	Sig. (2-tailed)	.	0.035	0.571
	N	42	42	42
Virtuality	***Correlation Coefficient***	0.327*	1.000	-0.240
	Sig. (2-tailed)	0.035	.	0.126
	N	42	42	42

*. CORRELATION IS SIGNIFICANT AT THE 0.05 LEVEL (2-TAILED).

CONCLUSION

The research and development requires higher levels of expertise within SMEs. Exchange knowledge and expertise can be created across virtual R&D teams. In principle, virtual teams could allow rapid decision-making to operate within SMES, regardless of the geographical location of its members. Although the infrastructure is ready for almost all SMEs, only one third of SMEs use internet connection facilities for establishing virtual R&D teams. So, the manager of R&D should take the potentials of virtual teams into account. Data from the Malaysian manufacturing SMEs sources shows, technologically SMEs capable of performing the virtual collaborative team. Despite the enormous benefaction of employ virtual R&D teams in manufacturing SMEs, applying the virtual teams by most enterprises, is still at its infancy.

This study is probably the first to present an empirical study on virtual R&D teams, which was limited to Malaysian manufacturing SMEs. The future research needs to investigate the correlations between the number of employees, virtuality and Internet connections by a larger sample from different sectors. The theme of virtual collaborative R&D teams has not been much explored and researchers in this field are encouraging to do more studies.

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African Journal of Business Management Vol. 4(11), pp. 2247-2257, 4 September, 2010
Available online at http://www.academicjournals.org/AJBM
ISSN 1993-8233 ©2010 Academic Journals

Full Length Research Paper

Critical factors for new product developments in SMEs virtual team

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Accepted 15 July, 2010

Small and medium enterprises (SMEs) are considered as an engine for economic growth all over the world and especially for developing countries. During the past decade, new product development (NPD) has increasingly been recognized as a critical factor in ensuring the continued survival of SMEs. On the other hand, the rapid rate of market and technological changes has accelerated in the past decade, so this turbulent environment requires new methods and techniques to bring successful new products to the marketplace. Virtual team can be a solution to answer the requested demand. However, literature have shown no significant differences between traditional NPD and virtual NPD in general, whereas NPD in SME's virtual team has not been systematically investigated in developing countries. This paper aims to bridge this gap by first reviewing the NPD and its relationship with virtuality and then identifies the critical factors of NPD in virtual teams. The statistical method was utilized to perform the required analysis of data from the survey. The results were achieved through factor analysis at the perspective of NPD in some Malaysian and Iranian manufacturing firms (N = 191). The 20 new product development factors were grouped into five higher level constructs. It gives valuable insight and guidelines, which hopefully will help managers of firms in developing countries to consider the main factors in NPD.

Key words: Survey findings, new product development, factor analysis, virtual team.

NTRODUCTION

New product development (NPD) is widely recognized as an essential property of the firm (Lam et al., 2007). Life cycle of products is decreasing every year and the customer demand, on the other hand, increased dramatically. With the need to respond quickly to customer requirements, increased complexity of product design and rapidly changing technologies, selecting the right set of NPD is critical to long-term success of the firm (Chen et al., 2008). Obviously, due to SMEs limited technical and financial capability, the situation will be even more severe for small and medium enterprises (SMEs) than large organizations (Mi et al., 2006). However, virtuality has been presented as a solution for SMEs to increase their competitiveness (Pihkala et al., 1999). The creation of a virtual team is an opportunity to reduce the time in reduce the time in marketing the new products and respond quickly to market demands. May and Carter (2001) in their case study of a virtual team working in the European automotive industry have shown that increasing communication and collaboration between geographically distributed engineers, automaker and supplier sites, which make them get benefits are better quality, lower costs and reduce time to market (from 20 to 50%) for a new vehicle product.

The ultimate objective of all NPD teams is their superior marketplace success of the new product (Akgun et al., 2006). Specialized skills and talents required for the development of new products often lie (and develop) locally in pockets of excellence around the company or even worldwide. Therefore, companies have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). The successful NPD requires companies to develop routines and practices to collaborate with suppliers, customers and employees of the cross-functional internal (Mishra and

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Shah, 2009). Consequently, companies find that the internal development of all technologies necessary for new products and processes are difficult or impossible. They must increasingly acquire technology from external sources (Stock and Tatikonda, 2004). Virtualization in NDP has recently begun to make serious progress due to developments in technology-virtuality in NPD now is technically possible (Leenders et al., 2003). Virtual NPD in SMEs is in its infancy in developing countries, and little research has been done on the introduction of the NPD in SMEs through a virtual team. So, we formed the topic that is somewhat lacking in the literature as a research gap.

The main objective of this paper is to present a model of critical factors of NPD in small and medium enterprises in developing countries. The rest of the paper is organized as follows:

The main concepts of new product development; reviews recent study on the relationship between NPD and virtuality; explores the importance of SMEs; presents the relationship between SMEs and virtual team; describes the research methodology; presents data collection, data analysis and discussion; and finally, it concludes the paper with some perspectives.

WHAT IS NEW PRODUCT DEVELOPMENT (NPD)?

The literature provided a number of definitions for what constitute a new product development (NPD). Product development definition is used by different researchers in slightly different ways (Ale Ebrahim et al., 2009b). Generally, it is the process that covers product design, pro-duction system design, product introduction processes and start of production (Johansen, 2005). Loch and Kavadias (2008) in the “Handbook of New Product Development Management” define NPD to “consists of the activities of the firm that lead to a stream of new or changed product market offerings over time. This includes the generation of opportunities, their selection and transformation into artifacts (manufactured products) and activities (services) offered to customers and the institutionalization of improvements in the NPD activities themselves”. According to the product development and management association (PDMA) glossary for new product development in the PDMA tool book 3 for new product development (Griffin and Somermeyer, 2007), NPD was defined as “the overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. Also, it is frequently referred to as product development”. Krishnan and Ulrich (2001) defined “product development as the transformation of a market opportunity and a set of assumptions about product technology into a product available for sale”. NPD has been described in a general form and there is no specified definition for new product development of SMEs virtual team in developing countries, which mean what is NPD, in SMEs virtual team, supposed to be in developing countries? This paper aims to extract the main factors of NPD in selective cases.

NPD AND VIRTUALITY

Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Badrinarayanan and Arnett, 2008). However, information technology (IT) improves NPD flexibility (Durmusoglu and Calantone, 2006). Ozer (2004) discussed that the internet facilitates and improves collaborations and thus increases the performance of new products. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams to develop new products is growing rapidly and can be dependent on organizations in maintaining a competitive advantage. On the other hand, competitive strategies are forcing companies to deploy their NPD resources globally, thus making collocated NPD teams prohibitively expensive and logistically difficult to manage (Susman et al., 2003). Susman et al. (2003) noted that research will increasingly focus on geographically dispersed NPD teams as their number will grow faster than collocated NPD teams. McDonough et al. (2001) argued that NPD teams are growing very fast, whereas virtuality affects the creative performance of NPD teams (Leenders et al., 2003). For example, Cisco has created the Cisco Collaboration Centre of Excellence to achieve its vision. Despite this industry attention, much is not yet understood about how to effectively collaborate virtuality to facilitate NPD (Susman and Majchrzak, 2003).

Some studies (Martinez-Sanchez et al., 2006) emphasized the challenges and difficulties experienced by virtual and conventional (for new product development) teams, which were not significantly different, although greater than the challenges and difficulties experienced by the in-house teams. NPD in SME’s virtual team has not been systematically investigated in literature. As a consequence, literature only, has not shown significant differences between traditional and virtual NPD in general. However, this paper aims to bridge this gap.

SMALL AND MEDIUM ENTERPRISES (SMES)

SMEs are a major part of the industrial economies (Eikebrokk and Olsen, 2007) and their survival and growth have therefore, being a prominent issue. The contributions of SMEs to employment and the countries’ gross domestic product (GDP) are highly significant

(Kotelnikov, 2007). Acs et al. (1997) argued that small firms are indeed the engines of global economic growth, whereas small and medium enterprises (SMEs) play an important role in promoting economic development. Many economists believe that the wealth of nations and the growth of their economies strongly depend on the performance of their SMEs (Schröder, 2006). In many developed and developing countries, small and medium-sized enterprises (SMEs) are the unsung heroes that bring stability to the national economy and help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003).

SMEs seem to be appropriate units when behaving like network nodes because of their lean structure, adaptability to market evolution, active involvement of versatile human resources, ability to establish a sub-contracting relation and good technological level of their products (Mezgar et al., 2000). In light of the above, SMEs have advantages in terms of flexibility, reaction time and innovation capacity that make them central actors in the new economy (Raymond and Croteau, 2006).

SMEs definition

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from country to country (O'Regan and Ghobadian, 2004). Table 1 illustrates a summary of SMEs definition in the manufacturing sector of selected countries. In most countries that are listed in Table 1, the definition is applicable to all sectors of the enterprises. Different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises (Ayyagari et al., 2007). At present, there seems to be no consensus on the definition of SMEs (Deros et al., 2006). In the absence of a definitive classification, an agreement has developed around the European Commission (EC) criteria for SME classification (O'Regan and Ghobadian, 2004). This definition adopts a quantitative approach emphasizing "tangible" criteria, employee numbers (up to 250 employees), turnover and balance sheet statistics (Tiwari and Buse, 2007). While turnover and balance sheet statistics are part of the criteria, the overriding consideration in practice appears to be an employee number based. Even if all three criteria were afforded equal consideration, it could be argued that the definition fails to take into account the attributes of a modern day small firm than to the medium-sized firm. The case studies employed here are SMEs in the Malaysian and Iranian manufacturing sector, which are chosen according to the EC definition of SMEs (Figure 1).

SMEs and virtual team

Past literature often hypothesized that SMEs were not innovated formally in recognized ways, and that they made much more extensive use of external linkages (Laforet and Tann, 2006; Hoffman et al., 1998). However, the SME is not a scaled-down version of a large company. It has different characteristics that distinguish it from large corporations and can of course change across different countries and cultures. Moreover, they are generally independent, multi-tasking, cash-limited and based on personal relationships and informality, as well as being actively managed by the owners, highly personalized, largely local in their area of operation and largely dependent on internal sources to finance growth (Perrini et al., 2007). To survive in the global economy, SMEs have to improve their products and processes by exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003). So if small firms want to make a step change in their technological and innovational base, they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to focus on core competencies for efficiency matters; however, they need to cooperate with external partners to compensate for other competencies and resources. This is especially the case in the field of new product development, where SMEs face specific problems in comparison to large firms (Pullen et al., 2008).

Despite the widespread publicity of information technology, the application of internet technology to upgrade and enhance the product design and business operation by most enterprises, especially for the small and medium sized enterprises, is still at its infancy (Zhan et al., 2003). The SMEs are one of the sectors that have a strong potential to benefit from advances in information and communication technologies (ICTs) and the adaptation of new business modes of operation (Miles et al., 2000). The use of ICTs can be considered as key factors for innovation and entrepreneurship; however, it is a must for SMEs to innovate ICTs (Redoli et al., 2008). More so, It is especially urgent for SMEs to construct a service platform of network to speed up the product development process (Lan et al., 2004). Collaboration is particularly critical when SMEs are involved with the aim of developing new products (Romero et al., 2008).

The success of developed countries can be attributed to factors relating to the emergence of new business technologies and cultures, such as virtual technology. This constituted the soft-technology complex that provided the environment for innovation and the effective application of technologies (Zhouying, 2005). Developing countries are, on the other hand, characterized by the absence of soft technology and limited abilities to make effective and efficient use of the technologies they obtain through a variety of transfer mechanisms, and to innovate and compete in the global market. Many SMEs have difficulties achieving successful innovation, despite having significant investment in research and development (O'Regan et al., 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible

Table 1. Definition of SMEs in the manufacturing sector of selected countries (Adopted from Ale Ebrahim et al., 2009a).

Country	Category of enterprise	Number of employee	Turnover	Other measure
European Commission (EC) criteria	Small	10 - 50	Less than € 10 (13.5 USD) million turnover	Balance sheet total: Less than € 10 (13.5 USD) million balance sheet total
European Commission (EC) criteria	Medium	Fewer than 250	Less than € 50 (67.6 USD) million turnover	Balance sheet total: Less than € 43 (58.2 USD) million balance sheet total
Indonesia	Small	5 – 19		Annual value of sales of a maximum of IDR1 billion (110,000 USD)
Indonesia	Medium	20 – 99		Annual value of sales of more than IDR1 billion, but less than IDR50 billion (5.5 million USD)
Iran	Small	Less than 10* Less than 50**		
Iran	Medium	10 - 100* 50 - 250**		
Japan		Less than 300		¥100 (1.1 USD) million assets
South Korea		Less than 300		
Malaysia	Small	5 to 50	Between RM 250,000 (75,000 USD) and less than RM 10 (3 USD) million	
Malaysia	Medium	50 to 150	Between RM 10 (3 USD) million and RM 25 (7.5 USD) million	
Philippines	Small	10 - 99		Between PHP 3 - 15 million (66,000 -330,000 USD) asset
Philippines	Medium	100 - 199		Between PHP 15 - 100 million (330,000 - 2.2 million USD) asset

*USD selected as a reference currency and the conversion is approximate.

assets, but more in those areas that will directly generate their future competitive advantage (for example, in R&D to generate knowledge, and in their employees' creativity to stimulate incremental innovations in already existing technologies). Moreover, the web-because of its easy access to large numbers of potential customers at reasonable cost may especially aid smaller companies that have not enjoyed the same national reach or financial resources as larger companies for market research (Buyukozkan et al., 2007). Levy et al. (2003) state that SMEs are knowledge creators but are poor in knowledge retention. They need to be proactive in knowledge sharing

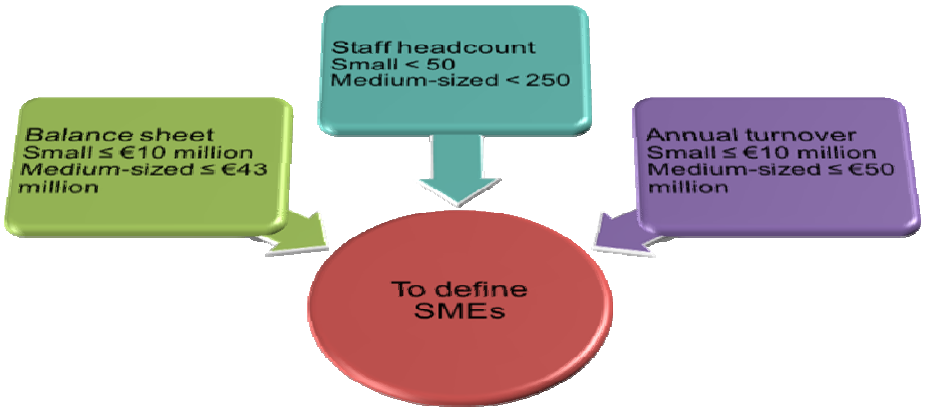

Figure 1. European Commission (EC) criteria for classification of SME (used in this research).

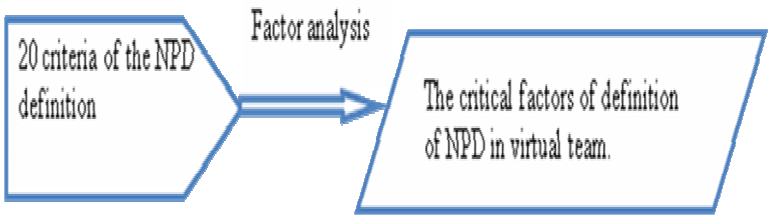

Figure 2. Research framework.

knowledge sharing arrangements in order to recognize that knowledge has value and that the value added is derived from knowledge exchange (Egbu et al., 2005).

RESEARCH METHODOLOGY

This research applied a statistical approach based on factor analysis and research framework (Figure 2). Factor analysis is a technique that attempts to identify underlying variables or factors that explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance that is observed in a much larger number of manifest variables. It is also suitable for analyzing the patterns of complex, multidimensional relationships encountered by researchers (Fathian et al., 2008).

Based on the main factors in NPD, 20 questions were derived from the literature review and an online questionnaire was designed. To help disentangle the concepts of new product development in the virtual team of SMEs, 20 individual criteria were asked from respondents (Table 2). These criteria have been grouped together through factor analysis to form the critical factors of NPD in virtual teams. The respondent asked a series of questions such as NPD 1: “Based on your organizations, is a new product/process development the use of things already known (reverse Engineering)? “

Data collection

The research target was manufacturing SMEs in Malaysia (M) and Iran (I) that are using the virtual team in their organization. In order to understand the viewpoints of SMEs on NPD, an online questionnaire has been sent to relevant SMEs in both countries. The rapid expansion of internet users has given web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002). Denscombe (2006) findings encourage social researchers to use web-based questionnaires with confidence, and the data produced by web-based questionnaires are equivalent to that produced by paper-based questionnaires. Other authors emphasized that the data provided by the internet methods are, at least, of good quality as those provided by traditional paper-and-pencil methods (Deutskens et al., 2006). However, minor differences occur between the two survey methods. Online respondents provided more improvement suggestions (Deutskens et al., 2006) which tended to be slightly longer than those from the paper version. As a result, the differences are not statistically significant (Denscombe, 2008).

The main sampling target was the managing director, R&D manager, the new product development manager, project and design manager and appropriate people who were most familiar with the NPD in the firm. For better understanding, the questionnaire has been prepared into different languages, that is, English and Persian. Consequently, the Iranian respondents could select either English or Persian version of the questionnaire. A total number of 3,625 e-mails have been sent to relevant SMEs and 686 of them clicked the online web page and answered the questionnaire. Out of 686 respondents, 190 SMEs responded completely and the rest answered partially. Table 3 summarized the online survey data collection. Only 121 firms met the criteria of SMEs definition in this research, so the rest of the respondents deducted from the factor analysis. A cross-tabulation descriptive statistics was employed to find the frequency and relationship between the country and

Table 2. Criteria (20) of the NPD.

Question	Criteria
NPD1	The entire R&D activities
NPD2	The use of things already known (Reverse Engineering)
NPD3	Making use of existing technologies (Adaptation)
NPD4	Increase efficiency of product
NPD5	Meet the role and regulation
NPD6	Improvement in product functionality/quality
NPD7	Improvements in elements of product technologies
NPD8	Major innovation in product technologies
NPD9	Major innovation in products as a whole
NPD10	Creation of new product concepts
NPD11	Improvement in the product process
NPD12	Reduction in quality problems
NPD13	Surprise or delight customers
NPD14	Replacing products that are phased out
NPD15	Extending product range
NPD16	Reducing production lead times
NPD17	Gaining new markets or market share
NPD18	Reducing labour costs
NPD19	Reducing material consumption
NPD20	Reducing energy consumption

Table 3. Summarized online survey data collection.

Numbers of e-mails sent to Malaysian (M) SMEs	Numbers of e-mails sent to Iranian (I) SMEs	Total e-mails sent to SMEs	Total responses (click the online web page)	Total responses/ sent (%)	Total completed	Total completed/ sent (%))	Total completed/ received (%)
2068	1557	3625	686	18.9	190	5.2	27.7

virtuality as illustrated in Table 4.

Data analysis

In the case of reliability analysis, Cronbach's (1951) alpha was employed to measure the internal consistency of the 20 factors. A reliability test was carried out to ensure that the research finding have the ability to provide consistent results. Cronbach's alpha for the 20 NPD factors was found within acceptable limits and was found to be 0.926, which means that there was a high reliability for the designed questions. In order to conclude whether the partial correlation of variables was small, the authors used the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Chi-square test of sphericity (Fathian et al., 2008). Table 5 summarized the results of KMO, which is 0.863 and the significant value of Bartlett's test in less than 0.05, which

Table 4. Cross-tabulation between country and virtuality.

			Virtuality NPD		Total
			Yes	No	
Country	Iran	Count	50	18	68
		% within country	73.5	26.5	100.0
	Malaysia	Count	19	34	53
		% within country	35.8	64.2	100.0
Total		Count	69	52	121
		% within country	57.0	43.0	100.0

Table 5. KMO and Bartlett's test results.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.863
Bartlett's test of sphericity	Approx. chi-square	961.993
	df	190
	Sig.	0.000

means there was a good correlation.

An exploratory factor analysis was conducted on 20 NPD factors using a principle component analysis with a varimax rotation and an Eigenvalue of 1 as the cut-off point (Akgün et al., 2008) and an absolute value of a factor loading that is greater than 0.5 (Fathian et al., 2008). The items and their factor loadings, after exploratory factor analysis, Eigenvalue and percentage of variance explained, appear in Tables 6 and 7. The 20 factors were grouped into five higher level constructs, which had an Eigenvalue greater than one.

DISCUSSION

The authors attempted to identify and named the confirmed factors based on the principle of being concise without losing clarity of meaning. After extracting the higher level constructs, variables with higher loadings are considered more important and have greater influence on the name of selected reduced factors. The names and contents of five derived factors are discussed.

Factor 1

It consists of NPD 17 to 20, which are “gaining new markets or market share“, “reducing labor costs”, “reducing materials consumption” and “reducing energy consumption”, respectively. This factor is named “process features”.

Factor 2

It consists of NPD 4, 5, 12 and 13, which are “increase efficiency of product”, “meet the role and regulation”, “reduction in quality problems” and “surprise or delight customers”, respectively. Since NPD 12 has higher loading (0.794), this factor was named “customer demand“.

Factor 3

It consists of NPD 2, 3, 7 and 15, which are “the use of things already known (reverse Engineering)”, “making use of existing technologies (adaptation)”, “improvements in elements of product technologies” and “extending product range”, respectively. This factor is named “technology features”.

Factor 4

It consists of NPD 6, 8, 10 and 11, which are “improvement in product functionality/quality”, “major innovation in product technologies”, “creation of new product concepts” and “improvement in the product process”, respectively. This factor is named “innovative process”.

Factor 5

It consists of NPD 1, 9, 14 and 16, which are “the entire R&D activities”, “major innovation in products as a whole”,

Table 6. Factor analysis results.

Component	Initial Eigen values			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	9.683	48.417	48.417	3.370	16.851	16.851
2	1.643	8.214	56.631	3.022	15.108	31.959
3	1.202	6.011	62.641	3.012	15.058	47.017
4	1.112	5.558	68.200	2.934	14.670	61.687
5	1.000	5.001	73.201	2.303	11.514	73.201
6	0.812	4.061	77.262			
7	0.767	3.837	81.099			
8	0.605	3.026	84.125			
9	0.546	2.729	86.854			
10	0.465	2.324	89.178			
11	0.400	1.998	91.176			
12	0.342	1.712	92.888			
13	0.322	1.609	94.497			
14	0.229	1.145	95.642			
15	0.225	1.123	96.764			
16	0.212	1.061	97.826			
17	0.149	0.746	98.572			
18	0.108	0.538	99.110			
19	0.091	0.455	99.565			
20	0.087	0.435	100.000			

Extraction method: Principal component analysis.

Table 7. Rotated component matrix sorted by size.

	Component (Cronbach's alpha) t				
	1 (.850)	2 (.821)	3 (.749)	4 (.790)	5 (.735)
NPD19	0.792	0.134	0.248	0.218	0.019
NPD18	0.762	0.287	0.232	0.103	0.227
NPD20	0.715	0.250	0.325	0.142	0.135
NPD17	0.515	0.364	-0.052	0.282	0.343
NPD12	0.278	0.794	0.313	0.155	0.203
NPD4	0.238	0.784	0.135	-0.288	0.069
NPD5	0.203	0.754	0.345	0.105	0.237
NPD13	0.379	0.462	0.280	0.275	0.453
NPD7	0.144	0.141	0.721	0.512	0.089
NPD2	0.372	0.218	0.706	0.148	-0.002
NPD3	0.169	0.258	0.670	0.165	0.219
NPD15	0.130	0.296	0.653	0.220	0.457
NPD10	0.149	-0.059	0.322	0.721	0.228
NPD8	0.186	0.205	0.332	0.710	0.040
NPD6	0.206	0.393	0.136	0.668	0.041
NPD11	0.528	0.308	-0.016	0.580	0.171
NPD14	0.126	0.117	0.542	0.267	0.649
NPD9	-0.016	0.237	0.180	0.546	0.604
NPD16	0.569	0.034	0.090	0.170	0.591
NPD1	0.380	0.335	0.114	-0.133	0.569

Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser Normalization.

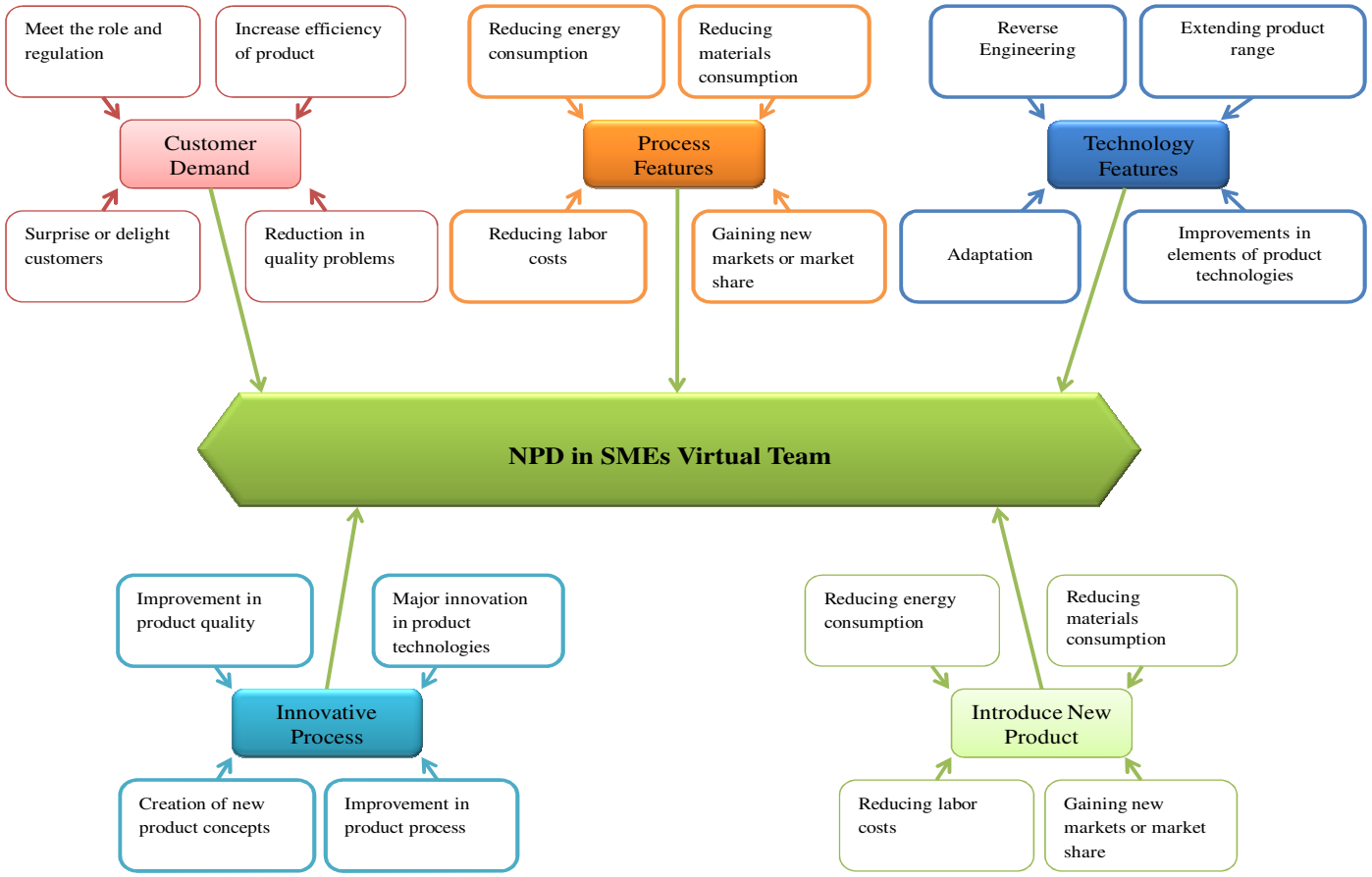

Figure 3. A conceptual model of NPD in SMEs virtual team (based on research results).

"replacing products that are being phased out" and "reducing production lead times", respectively. Since NPD 14 has been a higher loading (0.649), this factor was named "introduce new product".

All the aforementioned factors are summarized in Figure 3. This new conceptual model is based on data analysis of the survey findings. The conceptual model provides an overview of NPD understanding in SMEs (the ones which are familiar with virtuality) of some selected developing countries. Although more than half of the respondents are working on virtual team bases for new product developments, the virtual team application in SMEs is still in infancy. Slightly, more than 80% of the SMEs have not received an e-mail invitation to participate in an online survey (Table 3).

SMEs, especially in developing countries, severe from the lack of resources and manpower (Ale Ebrahim et al., 2009a) and as a result, the ability to consistently select the best factors to investigate, is therefore, vitally important to firms in the said countries. Hence, the manager of NPD team in SMEs has to optimize the new product process. This new conceptual model works as a tool to help a manager of the NPD team to focus on the major and important issues in NPD process, which lead to an increase in the efficiency of the procedure for new products. For academic researchers, this study contributes to a theoretical understanding of the factors that promote the diffusion of NPD in SMEs.

Conclusion

Factor analysis provides direct insight into the interrelationships between 20 variables and reduced it to five components. The first factor which is "process features" and which is a combination of "gaining new markets or market share", "reducing labour costs", "reducing materials consumption" and "reducing energy consumption", is more important than the rest four factors. So managers of firms in developing countries should consider the main factors in NPD. Customers demand (people) and technology features are respectively important after process issues. Therefore, going along with

Ebrahim et al. (2009c) recent research, people and process are more important in the virtual team than about technology.

Table 3 shows slightly, that above 18% of SMEs have received the online survey e-mail invitation. So it can conclude that most SMEs in the selected developing countries are still developing a new product in the traditional way, and they are not adopted with new information and communication technologies. As virtual NPD in SMEs is in its infancy in developing countries, it seems to be a necessary start for the introduction of the virtual team in the SMEs. The first step is perceived as NPD in this new environment, which is explored in this study.

This study is probably the first to present a conceptual model for the NPD issue in SMEs of the selected developing countries. The future research needs to investigate the model and verify it by a larger sample of SMEs from different sectors, since this study was limited to the manufacturing sector. In a larger sample, it is possible to compare the results between Iran and Malaysian SMEs.

ACKNOWLEDGEMENTS

This research was funded by a grant from the University of Malaya (Grant No. PS404/2009C) and the authors acknowledge this support. In addition, the authors are grateful to the editors and two anonymous reviewers for their helpful and insightful contributions on the first version of this document.

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Middle East FORUM
Issue 9, December 2009

DETERMINANTS OF FOREIGN DIRECT INVESTMENT IN IRAN: AN EMPIRICAL STUDY USING STRUCTURAL EQUATION MODELLING

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Abstract. This paper examines the determinants of foreign direct investment (FDI) in Iran by applying the structural equation modelling (SEM). Using the annual time series data for the 1991-2006 period, two models were developed. In the first model the correlation between 12 determining factors and FDI in Iran were analyzed and in the second model the 12 factors were fit into five categories of determinants namely: Business, Economic, Infrastructural, Oil and Science and Technology and the impact of each of the mentioned groups of factors was investigated.

The results derived through the first model indicated that openness of trade and Gross Domestic Product (GDP) per capita have a significant positive impact on FDI in Iran, while along with inflation, oil extraction and production had a surprisingly negative correlation with FDI. The results also suggested that infrastructural factors pertaining to telecommunications in addition to market size, research and development (R&D), education and the scientific output encourage FDI inflows in Iran.

The second model output estimates revealed that the business factors promote FDI most and interestingly once more the oil factor proved to have a negative impact on the FDI inflows to Iran.

Key words: Foreign Investment, Structural Equation Modelling, Iran

1. INTRODUCTION

Trans-national corporations (TNCs) have become central organizers of economic activities and major actors in shaping the international division of labour. They perform this role through foreign direct investment in the host country enterprises.

By most measures TNCs play a larger role in the world economy today than they did in the past in terms and in relation to key economic indicators such as gross domestic product (GDP), exports and domestic capital formation in the world economy as a whole and in the host countries both developed and developing (UNCTAD 1992).

FDI inflows can lead to a range of economic benefits for transitional and developing countries, including restructuring their economic activities in line with dynamic comparative advantage; reducing their costs of structural adjustment; raising the productivity of national resources and capabilities; improving quality standards and finally stimulating economic growth (Dunning 1994), (Jones, Fallon et al. 2000).

Various international organizations and foreign advisors recommend developing countries to rely primarily on foreign direct investment (FDI) as a source of external finance. They argue that, for several reasons, FDI stimulates economic growth more than other types of capital inflows. In particular, FDI is supposed to be less volatile, and to offer not just capital but also access to modern technology and know-how. However, it is surprisingly hard to support by empirical evidence this policy advice. Some studies find a positive relationship between FDI inflows and economic growth in host economies. (Caves 1996)

It is also widely accepted that FDI can have direct positive potential impact on host economies including the creation of well paid employment for scientists and engineers; better use of locally available materials; technology transfer (new equipment, laboratories, etc.); and the design of consumer products better suited to domestic needs, the development of new disciplines and specializations at local universities; the development of R&D clusters; and spin-offs of by-products that TNCs do not want to develop themselves.(UNCTAD 2005)

With around 1% of the population of the world, Iran currently possesses 7% of the world's natural reserves including 10% of the global proven oil reserves, 16% of the world's natural gas resources and has the largest natural gas resources worldwide after Russia.(BMI 2008)

The availability of these energy reserves and an abundance of natural resources provide an obvious locational advantage with respect to attracting FDI given the increasing importance of energy and other materials in the expanding global market. It offers prospects for lower costs for production facilities in Iran but also suggests a future concentration of R&D capability associated with these industries.

From the perspectives of the economies of scale involved in the activities of TNCs, many studies conclude that the size of the host country market measured by GDP or real GDP can put significantly positive influence on the flows of FDI into a region, in other words the bigger the market of an economy, the more FDI the region can attract.(Dunning 1993; Holland and Sass 2000; Durán and Ubeda 2001; Globerman and Shapiro 2002; Sun, Tong et al. 2002; Zhou and Lall 2005; Ang 2008)

Unlike most middle eastern countries such as UAE, Kuwait, Bahrain, Saudi Arabia and Turkey that will have negative or slight GDP per capita growth, Iran will have over 150% growth in the GDP per capita by 2012 (BMI 2008) considering the population growth of 1.5% (WB).

Keeping the above mentioned factors in mind, an expectation of growth in FDI inflows to Iran is realistic, however with the 901 M$ of inward FDI flow in 2006, the Islamic Republic of Iran stands at the 133rd position out of 141 economies (UNCTAD 2007). The relatively small scale of FDI inflows into Iran is also reflected in the two following diagrams.

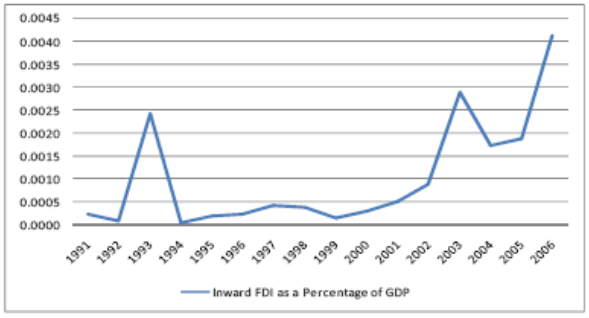

Figure 1- FDI inflows to Iran 1991-2006 (as a percentage of GDP)

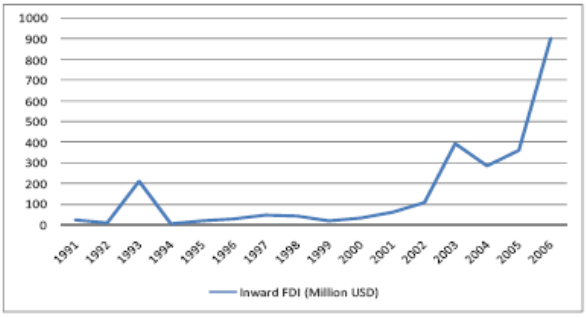

Figure 2- FDI inflows to Iran 1991-2006 (Million USD)

2. RESEARCH METHODOLOGY

Most of the previous studies of the determinants of FDI inflows have been based on a regression in the form of the following equation;

Equation 1

$$\mathrm{FDI}_i = \alpha_0 + \sum_{j=1}^{n} \alpha_j x_{ji} + \varepsilon_i$$

where FDI_i is inward foreign direct investment flows into country i and xji the jth explanatory variable of country i. These studies report a sample of regressions, including a certain set of explanatory variables. The problem is that theory (particularly the theory of FDI) is not adequately explicit about the variables that should appear in the "true" model. The following problem is often encountered: $x1$ may be significant when the regression includes $x2$ and $x3$, but not when $x4$ is included. So, which combination of all available xj's do we choose? Most, if not all, of the existing studies report the most "appealing" or convenient regression or regressions after extensive search and data mining, typically to confirm a preconceived idea (Moosa and Cardak 2006).

In order to build up the model and test the impact of the determining variables on FDI the structural equations modeling (SEM) as developed by Jöreskog (Jöreskog 1970), and extended by Goldberger & Duncan (Goldberger and Duncan 1973) was applied. SEM is a powerful technique that can combine complex path or simultaneous equation model and it includes confirmatory factor analysis and regression models.

The particular advantage of SEM is involving latent variables and as a result investigating causal theories as they pertain directly to the underlying constructs of interest, rather than to the measured variables whose observed relations are often attenuated by error of measurement.

Many researchers consider SEM to be a second generation statistical tool following multiple regression, factor analysis, and path analysis. Goldberger (Goldberger 1973) outlined three situations in which multiple regression falls short of structural equations: when the observed variables contain measurement errors and the interesting relationship is among the true variables; when there is interdependence or simultaneous causation among the observed response variables, and when important explanatory variables have not been included in the analysis.

As another advantage SEM enables researchers to answer a set of interrelated research questions by modeling the relationships among multiple independent and dependent constructs simultaneously. This capability for simultaneous analysis differs greatly from most first generation regression models which can analyze only one layer of linkages between independent and dependent variables at a time. Hence instead of testing the hypothesized relationships one by one, by applying SEM all the relationships among the model are tested simultaneously (Bollen 1989).

In addition, by applying SEM measurement error in the process of model building can be identified, estimated and then removed and by estimating and removing measurement error, the reliability of multiple indicators can be explicitly calculated within the analysis and more importantly the intricate causal networks enabled by SEM characterize real-world processes better than simple correlation-based models. Therefore, SEM is more suited for the mathematical modeling of complex processes to serve both theory and practice (Dubin 1976), (Gefen, Straub et al. 2000).

3. RESEARCH VARIABLES

Different sets of variables have been defined in the various studies conducted on determinants of FDI such as (Ang 2008), (Asiedu 2002), (Bevan and Estrin 2004),

(UNCTAD 1998), (Altomonte 2000), (Driffield and Noor 1999), (Ford and Strange 1999), (Holland and Sass 2000),(Nunnenkamp and Spatz 2002), (Zhou and Lall 2005), (Moosa and Cardak 2006), (Mina 2007), (Na and Lightfoot 2006), (Sun, Tong et al. 2002).

After an in-depth and a state of the art review of the existing literature while considering the availability of data and practicality of data collection in mind, the following variables were defined and calculated for Iran in the period between1991-2006. Table 1 and Table 2 summarize the variables, their indicators and the source of data.

Determining Factors	Latent Independent Variables	Observed (exogenous) Indicators	Data Source
	Market Size	GDP (Million USD)	(WB)
Economic	Purchasing Power	GDP Per Capita	(WB)
	Economic Risk	Inflation Rate	(IMF)
Infrastructure	Telecommunications	Fixed Line and Mobile Phone Subscribers per 1000 People	(WB)
Business	Trade Openness	(Import + Export)/GDP	(WB)
	Oil Exploitation	Crude Oil Production (1000 barrels per day)	(OPEC)
Oil	Oil Potential	Proven Crude Oil Reserves (Million Barrels)	(OPEC)
	Relative Oil Exploitation	Crude Oil Production/Reserves	(OPEC)
Science and	Innovation	Total Patent Applications Filed	(UNESCO)
Technology	R&D	Expenditure on R&D as a Percentage of GDP	(UNESCO)
	Education	Total Enrollments in All Tertiary Programs/ Population	(UNESCO)
	Scientific Out put	Journal Paper Publications	(NRISP)

Table 1-The Latent independent variables and their observed indicators

Latent Dependant Variable	Observed (endogenous) Indicator	Data Source
Inward FDI In Iran	Inward FDI (Million USD)	(UNCTAD 2007)

Table 2- The latent dependant variable and its observed indicator

4. MODEL DEVELOPMENT

On the basis of the data gathered two models were developed and tested, in Model 1 the impact of each individual factor on the FDI inflows to Iran was analyzed in order to get a micro view about the individual factors determining the FDI inflows and their level of significance. In model 2, all the independent variables were classified into five different categories as shown in Table 1and the impact of each category on the dependent variable (i.e. inward FDI) was investigated.

Both models were developed on the basis of General Model of Structural Equation Modelling. Figure 3 shows a general model of SEM, where, η (eta) represents the latent dependent, or endogenous, variables; ξ (ksi) represents latent independent, or exogenous, variables; Y represents the observed (endogenous) indicators of the dependent latent variables η; x represents the observed (exogenous) indicators of the independent latent variables; ε (epsilon) is a *p* x 1 measurement errors in an observed endogenous variable y; (delta) is a *q* x 1 vector of measurement errors in an observed exogenous variable x; **λ(y)** (lamda y) represents coefficients of the regression of y on η; **λ(X)** (lamda x) represent the coefficients of the regression of x on ξ.

a. Model 1

Figure 4 illustrates model 1 w here X1-X1 2 are the observed indicators for the latent independent variables of ξ−ξ 2 as explained in Table 1. For instance ξ_3 represents economic risk which as a latent independent variable for which inflation (X_3) is the obseved indicato r. η represents the latent dependent variable of inward F DI to Iran which has been indicated by the observed variable of Y that represent Inward FDI (Million USD).

b. Model 2

As shown in Figure 5, in Model 2, the determining factors of Inward FDI as listed in Table 1; namely economic, infrastructure, business, oil and science and technology have been considered as the latent independent variables and respectively represented by ξ− ξ_5, while their observed indicators X_1-X_{12} and the latent dependent variable and its indicator are similar to Model 1.

5. RESULTS

The models were developed by means path diagram of LISREL 8.53 software[1], and afterwards the covariance matrices of the gathered data were calculated and the model was r un. Table 3 and Table 4 report t he path coefficients high lighting the

correlation between the latent variables and the pertinent T Values in Model 1 a nd Model 2 respectively.

Latent Independent Variable	Path Coefficient	T Values*
Trade Openness	0.72	11.28
Telecommunications	0.70	12.88
Purchasing Power	0.68	19.55
Market Size	0.61	18.44
Scientific Out put	0.59	19.42
R&D	0.52	10.92
Innovation	0.42	18.31
Oil Exploitation	-0.42	14.22
Education	0.41	10.11
Economic Risk	-0.39	14.38
Relative Oil Exploitation	0.32	11.21
Oil Potential	-0.30	11.30
* Significant at level 0.01		

Table 3- Model 1 Results

Latent Independent Variable	Path Coefficient	T Values*
Business Factor	0.79	19.29
Economic Factor	0.75	17.79
Infrastructural Factor	0.59	12.77
Oil Factor	- 0.49	24.77
Science and Technology	0.47	8.21
* Significant at level 0.01		

Table 4- Model 2 Results

	Model 1	Model 2
X^2	102.22	154.78
RMSEA[1]	0.013	0.015
CFI[2]	0.95	0.96
NFI[3]	0.92	0.94
GFI[4]	0.94	0.95
AGFI[5]	0.92	0.94

Table 5- Models Fit Indices

LISREL provides several indications of the extent to which the sampled data fits the researcher-specified model. In the case of model 1 and 2 the fit indices, as summarized in Table 5, indicate that the models are reasonably good-fitting models based on the acceptable range of fit indices in LISREL as discussed extensively by Bentler (Bentler 1990) and Hoetler (Hoetler 1983) .

1 - Root Mean Square Error for Approximation
2 - Comparative Fit Index
3 - Normed Fit Index
4 - Goodness of Fit Index
5 - Adjusted Goodness of Fit Index

6. CONCLUSION AND POLICY IMPLICATIONS

Trade openness contributes significantly positively to FDI inflows in Iran; hence policy improvements with respect to business ease and trade liberalization will undoubtedly result in higher FDI inflows. Therefore it can be implied that more FDI-friendly regulatory improvements shall be implemented with the purpose of trade facilitation and business ease if Iran is to adopt a welcoming stance to FDI inflows.

Based on the empirical results, market factors promote FDI inflows to Iran significantly. It was also observed that economic risk indicated by inflation serves as an obstacle to FDI inflows with a substantially negative correlation coefficient. In other words investors are attracted to growth in Iran's GDP and GDP per capita and react negatively towards any increase in Iran's inflation.

The empirical evidence also points to the importance of infrastructure base in particular telecommunications infrastructure. Therefore the availability of fixed and mobile phone lines besides broad band internet connection promote Iran as a prospective investment location.

As might have been expected, research and development along with other S&T indicators promote FDI to a relatively high degree although their impact is not as high as business and economic factors. This can serve to highlight the fact that FDI in Iran has been more of a resource and market seeking types than an efficiency seeking which can be interpreted as a threat by the emergence of knowledge and innovation as the key competitive advantages in global business environment.

Hence developing a national culture supportive of invention, risk-taking, entrepreneurship and research in addition to orienting the support budget to R&D in an enterprise scale can definitely serve to enhance the overall S&T perspective of Iran. It is also recommended that a new and less bureaucratic approach to R&D support is established so that a systematic and continuous approach to R&D within enterprises is encouraged.

Surprisingly oil exploitation and oil potential were proven to impact FDI in flows negatively while the analysis suggest that increase in relative oil production leads to more FDI inflows. The findings of this research pertaining to the impact of oil factors on FDI inflows can be subject to a new research in order to track the dynamic impact of oil on Iran's economy and Iran's perceived attractiveness as a location for foreign investment.

It should also be noted that due to unavailability of empirical data, political factors such as Iran's political stability and the influence of the sanctions were not incorporated within the research framework. Since the impact of such political issues is considerably significant in the macroeconomic perspective of a country and the perceived investment risk, further research needs to be carried to clarify the extend to which political factors can influence FDI inflows in Iran.

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International Journal of the Physical Sciences Vol. 5(7), pp. 916-930, July 2010
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 ©2010 Academic Journals

Review

SMEs; Virtual research and development (R&D) teams and new product development: A literature review

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Accepted 10 June, 2010

Small and medium-sized enterprises (SMEs) are indeed the engines of global economic growth. Their continued growth is a major subject for the economy and employment of any country. Towards that end, virtual research and development (R&D) could be a viable option to sustain and ease the operations of SMEs. However, literature shows there has not been a great deal of research into the diverse characteristic of virtual R&D teams in SMEs. This article provides a comprehensive literature review on different aspects of virtual R&D teams collected from the reputed publications. The purpose of the literature review is to provide an outline on the structure and dynamics of R&D collaboration in SMEs. Specifying the rationale and relevance of virtual teams, the relationship between virtual R&D team for SMEs and new product development (NPD) has been examined. It concludes with identifying the gaps and feebleness in the existing literatures and calls for future research in this area. It is argued to form of virtual R&D team deserves consideration at top level management for venturing into the new product development within SMEs.

Key words: Virtual teams, small and medium enterprises, new product development, R&D.

INTRODUCTION

SMEs can successfully enter and remain in the global market if they can fulfill the customer needs for features and quality of products (Kusar et al., 2004). Their survival depended on their ability to market response, meeting performance and producing goods that could meet international standards (Gomez and Simpson, 2007). In other words, certain competitiveness may be a precondition for an SME's survival when dealing with dynamic conditions in the business environment. To compete with global competition and overcome the rapid technology change and product variety expansion in the new manufacturing environment, SMEs must be able to continue in product innovation (Laforet, 2008). One important trend is to enable them to create new knowledge and transfer that into reality. The SMEs are one of the sectors that have a strong potential to benefit from advances in Information and Communication Technologies (ICTs) and to adapt new business. A suitable combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtual invention (Miles et al., 2000). Use of ICTs can be considered as a key factor for innovation and entrepreneurship. ICTs are indispensable for SMEs to innovate (Redoli et al., 2008). Web services can help the enterprises to get external service resources and carry out collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to make a network service platform to speed up the product development (Lan et al., 2004).

Internationalization of R&D Network is a recent phenomenon (Salmela and Lukka, 2004). International collaboration in R&D is, however, becoming increasingly important in creating knowledge that makes research and business more competitive. Under the pressure of globalize competition forces, producers are continuously innovating and upgrading the quality of their existing products.

Organizations are facing unprecedented challenges in an ever dynamic, constantly changing and complex environment (Rezgui, 2007). In this knowledge-based environment, the driving forces for this phenomenon are digitization, the Internet and high-speed data networks that are keys to addressing many operational issues from

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design to logistics and distribution (Noori and Lee, 2006). Networking, outsourcing and information and communication technology is considered as general tools and means to respond to these challenges (Salmela and Lukka, 2004). From the other direction, surviving in the competitive industry needs strategies to collaborate or compete with suitable firms within a network in an NPD (Chen et al., 2008a). As a result multinational enterprises have increased their R&D investment in foreign countries (Reger, 2004).

Responding to the increasing decentralization and globalization of work, many organizations have responded to their dynamic environments by introducing virtual teams. Virtual teams are growing in popularity (Cascio, 2000).

Additionally, the rapid development of new communication technologies such as the internet has speeded up this trend so that today, most of the large organizations employ virtual teams to some degree (Hertel et al., 2005). Considering that under the increasingly competitive global market, a firm simply cannot survive without new products developed under network cooperation, especially for high-tech industries (Chen et al., 2008b). Keeping virtual R&D teams in NPD processes, operating innovatively, effectively and efficiently is of a high importance, but the issue has poorly been addressed simultaneously in the previous studies.

While some studies have been conducted on usage of a certain model in large companies, applications within SMEs have remained largely un-documented. A few studies exclusively focused on the virtual R&D teams, for example (Tribe and Allen, 2003; Gassmann and Von Zedtwitz, 2003b; Kratzer et al., 2005; Gassmann and Von Zedtwitz, 1999) and none of them concentrated on the virtual R&D teams for NPD in SMEs. So, literature shows that there has not been a great deal of research into the diverse characteristic of virtual R&D teams in SMEs, which are still ambiguous. This extensive review shows that limited work had been directed towards exploring and analyzing the existing inter-relation among virtual R&D teams and NPD in SMEs. Therefore, this paper summarized the key findings of earlier works on different aspects of virtual R&D teams in SMEs and establishes it a rationale in NPD. It provides the gaps and weaknesses in the existing literature on virtual R&D teams in new product development within SMEs. Base on the literature review, we then propose suggestions for future research.

REVIEW SEARCH METHOD

Collaborative R&D involving SMEs have wide coverage. It applies to various activities ranging from information exchange to new product development. This review article is based on dependable and reputed publications. It mainly covers aspects like SMEs characteristics, scope of virtual R&D teams and their relationship in NPD. The articles are collected from the following two sources:

(1) Reputed journals, books and practitioners' literatures related to the topic published since 1997.
(2) Research papers presented in various conferences focusing on R&D and SMEs activities, NPD and technology management issues.

As there is no single definition of collaborative virtual R&D team in SMEs that involves NPD, there is a lack of specific research on the subject. A few studies were done on R&D collaborations in multinational companies. Therefore, in order to find out structures, dynamics and management intervention in the field, a broader spectrum of literature has been considered. This review covered literatures in the areas of collaborative R&D in general, its relevance with SMEs, NPD in SMEs and virtuality. The current understanding and thinking about SMEs, virtual R&D teams and NPD are found at the intersection of these separate fields, as showed in Figure 1.

The investigation limited to the reputed publication since 1997 is not included in the other sources such as magazines and white papers. The list of references contains 200 items out of 345 selected items, which were extracted from 1,118 pre-investigated items. To find relevant academic publications, some multidisciplinary databases were used. To find the relevancy a set of keywords from a general model which is shown in Figure 1 were used. The general model for SMEs; virtual R&D teams and NPD enable a systematic integration of the fragmented literature on the topic. There is no consensus in the literature is whether virtual teams are superior at SMEs or not. We argue that lack of SMEs will be sheltered by virtual teams. The distribution of reviewed articles per publication year shows that 2007 was an outstanding date for research on topic Figure 2. The trend of publication shows virtual R&D team in SMEs for NPD is an interesting topic in recent years.

VIRTUAL TEAMS

Although virtual teamwork is a current topic in the relevant literature on global organizations but defining 'virtual' is still unsettled across multiple institutional contexts (Chudoba et al., 2005). The concept of a "team" is described as a small number of people with complementary skills who are equally committed to a common purpose, goal and working approach for which they hold themselves mutually accountable (Zenun et al., 2007). It is worth mentioning that virtual teams are often formed to overcome geographical or temporal separations (Cascio and Shurygailo, 2003). Virtual teams work across boundaries of time and space by utilizing modern computer-driven technologies. The term "virtual team" is used to cover a wide range of activities and forms of

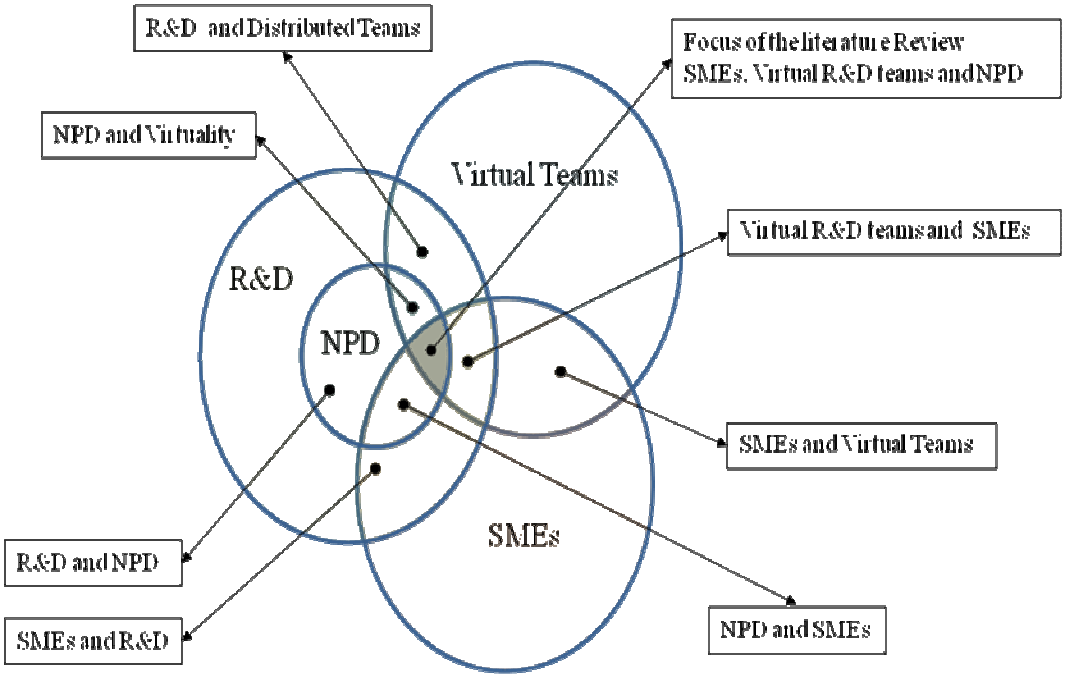

Figure 1. Literature fields included in the review: A general model.

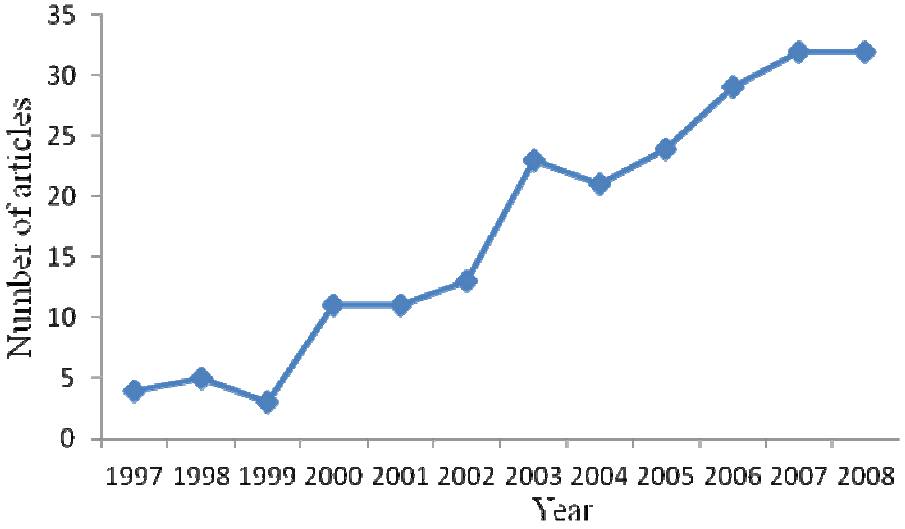

Figure 2. Publication trend.

technology-supported functions (Anderson et al., 2007). Gassmann and Von Zedtwitz (2003b) defined "virtual team as a group of people and sub-teams which interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies". Another definition of virtual teams, "… distributed work teams whose members are geographically dispersed but coordinate their work, predominantly with electronic information and communication technologies (E-mail, video-conferencing, telephone, etc.) (Hertel et al., 2005)". However, among different definitions of a virtual team, the following one is the most widely accepted (Powell et al., 2004), ''virtual teams as groups of geographically, organizationally and/or time dispersed people brought together by information technologies to accomplish one

or more organization tasks". It is generally accepted that virtual teams form socio-technical systems (Curseu et al., 2008). From these are other definitions, the key terms in virtual teams are:

A group of people (may belong to different companies (Dafoulas and Macaulay, 2002) who interact through interdependent tasks to achieve common goals (Gassmann and Von Zedtwitz, 2003b), while geographically, organizationally and/or time dispersed (Leenders et al., 2003), work mainly using communication technologies (Hertel et al., 2005), for short-term and perpetual (Baskerville and Nandhakumar, 2007).

Team and innovation

It is a widely accepted fact that innovation is better achieved by working in teams (Sorli et al., 2006). Most of the successful innovations are developed through the collective efforts of individuals in NPD teams (Akgun et al., 2006). All teams and virtual teams in particular, must develop mechanisms for sharing knowledge, experiences and insights critical for accomplishing their missions (Rosen et al., 2007). Virtual teams offer business applications that make the concurrent design of the products and development process feasible as well as responsive to variations and changes in product/process information (Mulebeke and Zheng, 2006).

Benefit of virtual teams

Virtual teams reduce time-to-market (Lipnack and Stamps, 2000; May and Carter, 2001; Sorli et al., 2006; Kankanhalli et al., 2006; Chen, 2008; Shachaf, 2008; Kusar et al., 2004; Ge and Hu, 2008; Mulebeke and Zheng, 2006; Guniš et al., 2007; Prasad and Akhilesh, 2002; Zhang et al., 2004; Sridhar et al., 2007). Lead time or time-to-market has been generally admitted to being one of the most important keys for the success in manufacturing (Sorli et al., 2006). Time also has an almost 1:1 correlation with cost, so cost will be proportionally reduced if the time-to market is quicker (Rabelo and Jr, 2005). Virtual teams can overcome the limitations of time, space and organizational affiliation that traditional teams face (Piccoli et al., 2004) and reduce transfer time and costs and travel costs (McDonough et al., 2001; Rice et al., 2007; Bergiel et al., 2008; Cascio, 2000; Fuller et al., 2006; Kankanhalli et al., 2006; Prasad and Akhilesh, 2002; Olson-Buchanan et al., 2007; Boudreau et al., 1998; Biuk-Aghai, 2003; Liu and Liu, 2007; Lipnack and Stamps, 2000). Virtual teams overcome the limitations of time, space and organizational affiliation that traditional teams face (Piccoli et al., 2004). One of the most important of employ virtual R&D team can tap selectively into a centre of excellence, using the best talent regardless of location (Criscuolo, 2005; Cascio, 2000; Samarah et al., 2007; Fuller et al., 2006; Furst et al., 2004; Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002; Boudreau et al., 1998; Boutellier et al., 1998).

Also, virtual teams respond quickly to changing business environments (Bergiel et al., 2008; Mulebeke and Zheng, 2006), able to digitally or electronically unite experts in highly specialized fields working at great distances from each other (Rosen et al., 2007), make R&D continuation decisions more effective (Cummings and Teng, 2003; Schmidt et al., 2001), provide greater degree of freedom to individuals involved with the development project (Ojasalo, 2008; Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002). Creating greater productivity, shorter development times (McDonough et al., 2001; Mulebeke and Zheng, 2006), producing better outcomes and attracting better employyees are other benefits of virtual teams. Further, such teams can generate the great competitive advantage from limited resources (Martins et al., 2004; Rice et al., 2007; Chen et al., 2008c), useful for projects that require cross-functional or cross boundary skilled inputs (Lee-Kelley and Sankey, 2008), less resistant to change (Precup et al., 2006), helping transnational innovation processes (Gassmann and Von Zedtwitz, 2003b; Prasad and Akhilesh, 2002) and higher degree of cohesion (teams can be organized whether or not members are in proximity to one another) (Kratzer et al., 2005; Cascio, 2000; Gaudes et al., 2007), evolving organizations from production-oriented to service/information-oriented (Johnson et al., 2001; Precup et al., 2006) and providing organizations with an unprecedented level of flexibility and responsiveness (Powell et al., 2004; Hunsaker and Hunsaker, 2008; Chen, 2008; Guniš et al., 2007; Prasad and Akhilesh, 2002; Pihkala et al., 1999; Piccoli et al., 2004; Liu and Liu, 2007). Besides, virtual teams are self-assessed and high performance teams (Chudoba et al., 2005; Poehler and Schumacher, 2007), employees can more easily accommodate both personal and professional lives (Cascio, 2000), employees perform their work without concern of space or time constraints (Lurey and Raisinghani, 2001), optimize the contributions of individual members towards the completion of business tasks and organizational goals (Samarah et al., 2007), reduce the pollution (Johnson et al., 2001), manage the development and commercialization tasks quite well (Chesbrough and Teece, 2002), improve communication and coordination and encourage the mutual sharing of inter-organizational resources and competencies (Chen et al., 2008a), cultivating and managing creativity (Leenders et al., 2003; Prasad and Akhilesh, 2002; Atuahene-Gima, 2003; Badrinarayanan and Arnett, 2008), facilitate knowledge capturing and sharing and experiences (Rosen et al., 2007; Zakaria et al., 2004; Furst et al., 2004; Merali and Davies, 2001; Sridhar et al., 2007; Lipnack and Stamps, 2000), improve

the detail and precision of design activities (Vaccaro et al., 2008), provide a vehicle for global collaboration and coordination of R&D-related activities (Paul et al., 2005), allow organizations to access the most qualified individuals for a particular job regardless of their location (Hunsaker and Hunsaker, 2008) and enable organizations to respond faster to increased competition (Hunsaker and Hunsaker, 2008; Pauleen, 2003).

The ratio of publications from virtual R&D member is more exceeded from co-located publications (Ahuja et al., 2003) and the extent of informal exchange of information is minimal (Pawar and Sharifi, 1997; Schmidt et al., 2001). Virtual teams have better team outcomes (quality, productivity and satisfaction) (Gaudes et al., 2007; Ortiz de Guinea et al., 2005; Piccoli et al., 2004), reduce training expenses, faster learning (Pena-Mora et al., 2000; Atuahene-Gima, 2003; Badrinarayanan and Arnett, 2008) and finally greater client satisfaction (Jain and Sobek, 2006). These benefits are not entirely new. The key advantages in virtual teams are that they can reduce time-to-market, increase in flexibility and team formation.

Pitfall of virtual teams

Virtual R&D teams in which members do not work at the same time or place often faces tight schedules and a need to start quickly and perform instantly (Munkvold and Zigurs, 2007). Virtual team may allow people to collaborate with more productivity at a distance, but the trip to a coffee corner or across the hallway to a trusted colleague is still the most reliable and effective way to review and revise a new idea (Gassmann and Von Zedtwitz, 2003a). As a drawback, virtual teams are vulnerable to mistrust, communication breakdowns, conflicts and power struggles (Rosen et al., 2007; Cascio, 2000; Kirkman et al., 2002; Taifi, 2007; Baskerville and Nandhakumar, 2007). It sometimes requires complex technological applications (Bergiel et al., 2008; Badrinarayanan and Arnett, 2008) and has a lack of physical interaction (Cascio, 2000; Hossain and Wigand, 2004; Kankanhalli et al., 2006; Rice et al., 2007). In virtual teams, everything to be reinforced in a much more structured, formal process (Lurey and Raisinghani, 2001) but decrease monitoring and control of activities (Pawar and Sharifi, 1997).

Virtual teams comprise of challenges of project management (Wong and Burton, 2000; Martinez-Sanchez et al., 2006; Badrinarayanan and Arnett, 2008; Jacobsa et al., 2005), finding out the suitable task technology fit (Qureshi and Vogel, 2001; Ocker and Fjermestad, 2008; Griffith et al., 2003; Badrinarayanan and Arnett, 2008; Bell and Kozlowski, 2002), managing conflict (Hinds and Mortensen, 2005; Ocker and Fjermestad, 2008; Kayworth and Leidner, 2002; Piccoli et al., 2004; Wong and Burton, 2000; Ramayah et al., 2003) and technophobia (employees who are uncomfortable with computer and other telecommunications technologies) (Johnson et al., 2001). Cultural diversity in virtual teams leads to differences in the members thought processes. Therefore, develop trust among the members are challenging (Bell and Kozlowski, 2002; Griffith et al., 2003; Shachaf, 2005; Jacobsa et al., 2005; Paul et al., 2005; Poehler and Schumacher; 2007; Kankanhalli et al., 2006; Badrinarayanan and Arnett, 2008; Munkvold and Zigurs, 2007; Boutellier et al., 1998). Variety of practices (cultural and work diversity) and employee mobility negatively impacted performance in virtual teams (Chudoba et al., 2005). Team members need special training and encouragement (Ryssen and Godar, 2000).

RESEARCH AND DEVELOPMENT (R&D)

Nowadays, unpredictable economic and business environment suggests that many firms seek new ways of conducting their business through some innovation to make a profit and stay ahead of the competition (Laforet, 2008). Around the world, innovation is now recognized as a prime source of competitive advantage (Hegde and Hicks, 2008). R&D is a strategy for developing technologies that can be commercialized under independent intellectual property rights. R&D enable firms to create new technologies and/or to build on existing technologies gained through technology transfer (Zhouying, 2005). R&D efforts are necessary to realize various goals (Robinson and Propp, 2008). R&D is an endless process for any forward thinking technology-based companies.

Innovative development of the existing products is advisable to keep ahead of advances that competitors may be making. Further, when a potential customer approaches a firm outlining its needs for a product, R&D may be required to fulfill the request (Lawson et al., 2006). The success of a company's R&D effort is strongly related to the uniqueness of the product, both product functions and technical aspects (Kratzer et al., 2005). Research is an investment, not an expense (Boer, 2005). Large amount of money is spent all over the world on R&D, to ensure future sustainability (Precup et al., 2006). From different points of view, the increasing complexity and inter-disciplinary nature of R&D process in turn has increased the cost of research. Therefore, research becomes less attractive without partners to share the cost (Howells et al., 2003).

R&D and distributed team

R&D are now dependent to different location drivers (Von Zedtwitz and Gassmann, 2002). Many firms started to earn their knowledge from external sources (Erkena and Gilsing, 2005). R&D units in foreign countries have

gained more responsibilities and competencies besides the still-existing traditional mode of product developed adapted in the home country and technical support for production in abroad (Reger, 2004). Trends in the last decade had shown China and India were emerging as attractive R&D destinations for the USA (Hegde and Hicks, 2008).

Changes in telecommunications and data processing abilities make it possible to coordinate research, marketing and production operation around the world (Acs and Preston, 1997). Hegde and Hicks (2008) noted that overseas R&D sites are auxiliary outposts, subservient to home R&D laboratories. “Corporate growth and positioning” and “knowledge sourcing” are two forces, which result in companies with a more global R&D nature (Richtne´r and Rognes, 2008). Technological change is a highly dynamic process that may quickly move to take the advantage of ideal conditions for growth (Hegde and Hicks, 2008). For most R&D teams, being virtual are a matter of degree (Leenders et al., 2003).

SMALL AND MEDIUM ENTERPRISES (SMEs) VIRTUAL TEAMS

SMEs play an important role to promote economic development. Acs, et al. (1997) inferred that small firms are indeed the engines of global economic growth. In most countries, SMEs dominate the industrial and commercial infrastructure (Deros et al., 2006). More importantly SMEs play an important role in flows of foreign direct investment (FDI) (Kuo and Li, 2003). Economists believe the wealth of nations and the growth of their economies strongly depend on their SMEs’ performance (Schröder, 2006). In many developed and developing countries, SMEs are the unsung heroes that bring stability to the national economy. They help buffer the shocks that come with the boom and bust of economic cycles. SMEs also serve as the key engine behind equalizing income disparity among workers (Choi, 2003). China’s recent rapid growth is also linked to emerging many new small firms in village townships and in coastal areas, often named new industries (Acs et al., 1997).

To survive in the global economy SMEs have to improve their products and exploiting their intellectual capital in a network of knowledge-intensive relations inside and outside their borders (Corso et al., 2003).Hanna and Walsh (2002) noted that if small firms want to make a step-change in their technological and innovation base, they have to rethink their approach to cooperation. SMEs need proper and up-to-date knowledge to compete and there is a strong need to create, share and disseminate knowledge within SME’s (Nunes et al., 2006).Especially, in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development (Blomqvist et al., 2004). The key elements in knowledge-sharing are not only the hardware and software, but also the ability and willingness of team members to actively take part in the knowledge-sharing (Rosen et al., 2007). Dickson and Hadjimanolis (1998) examined innovation and networking among small manufacturing companies. They found some tentative evidence that companies performing at “the local strategic network” are more innovative than those operating in terms of “the local self-sufficiency”. In the beginning of R&D activities SMEs always face capital shortage and need technological assistance.

Most firms today do not perform alone; they are networked vertically with many value chain partners (Miles et al., 2000). The typical Taiwanese production system has a cooperative network of SMEs that are flexible and quick responsive, although under-capitalized and sensitive to market demand and highly integrated in the global economy (Low, 2006). Strategic alliance formation has been touted as one of the most critical strategic actions that SMEs must undertake for survival and success (Dickson et al., 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets, but more in those areas such as R&D that will directly generate their future competitive advantage.

Virtual R&D teams in SMEs

Most SMEs are heavily reliant on external sources, including customers and suppliers, for the generation of new knowledge (Jones and Macpherson, 2006). SMEs of all sizes must reach out into their external environment for necessary resources (Dickson et al., 2006). In the present era of globalization, it is obvious the survival of the SMEs will be determined by their ability to manufacture and supply more, at competitive cost, in less delivery time, with minimum defects, using fewer resources (Sharma and Bhagwat, 2006). To face this challenge, SMEs can reinforce knowledge to create synergies that allow firms to overcome difficulties and succeed. This may lead to new relationships between different agents to overcome scarcity and/or difficulties in gaining access to resources (Gomez and Simpson, 2007).

The combination of explosive knowledge growth and inexpensive information transfer creates a fertile soil for unlimited virtual invention (Miles et al., 2000). Web resource services can help the enterprises to get external service resources and impose collaborative design and manufacturing (Dong and Liu, 2006). It is especially urgent for SMEs to construct a service platform of networked to speed up the product development (Lan et al., 2004). Sharma and Bhagwat (2006) study results reveal that IT in SMEs is still in a backseat even though the use of computers is continuously increasing in their

Table 1. Some of the major advantages of SMEs.

Advantages	References
Generally dominated by the entrepreneur (owner-manager)	(Jones and Macpherson, 2006; Schatz, 2006; Egbu et al., 2005; Kotey and Slade, 2005; Bougrain and Haudeville, 2002; Love and Irani, 2004; Sarosa and Zowghi, 2003)
Able to respond quickly to customer requests and market changes, Customers focused	(Jones and Macpherson, 2006; Schatz, 2006; Levy and Powell, 1998; Mahemba and Bruijn, 2003; Wu et al., 2007; Canavesio and Martinez, 2007; Huang et al., 2004; Abdul-Nour et al., 1999)
Flexible and fast-response to change, easily adaptive to new market conditions , dynamic in behavior, developing customized solutions for partners and customers	(Narula, 2004; Schatz, 2006; Deros et al., 2006; Mezgar et al., 2000; Levy and Powell, 1998; Nieto and Fern´andez, 2005; Sarosa, 2007; Davis and Sun, 2006; Starbek and Grum, 2002; Abdul-Nour et al., 1999, Aragón-Sánchez and Sánchez-Marín, 2005).
Concentrated production and sales in their home country	(Narula, 2004; Perrini et al., 2007).
Driven by client demands	(Lawson et al., 2006; Schatz, 2006; Deros et al., 2006; Axelson, 2005)
Quick decision-making (decisions are made by an individual or a few people, or a single individual)	
It strongly correlated and inter-related with respect to Innovation and entrepreneurship.	(Robles-Estrada and Gómez-Suárez, 2007; Sharma and Bhagwat, 2006; Gray, 2006; Gunasekaran et al., 1999; Bodorick et al., 2002; Huang et al., 2001, Chew and Yeung, 2001)
High innovatory potential	
More extensive use of external linkages for Innovate.	(Laforet and Tann, 2006, Hoffman et al., 1998, Barnett and Storey, 2000)
Un bureaucratic processes, flat and flexible structures	(Haga, 2005, Axelson, 2005, Schatz, 2006, Sharma and Bhagwat, 2006, Deros et al., 2006, Levy and Powell, 1998, Axelson, 2007, Massa and Testa, 2008)
Strong inter and intra-firm relationships , managing a great amount of information	(Carbonara, 2005, Chen et al., 2007)
Good at multi-tasking	(Schatz, 2006; Axelson, 2007)
Focused on gaining instant gratification with technology solutions.	(Schatz, 2006)
Informal and dynamic strategies	(Sharma and Bhagwat, 2006)
Capable of going international early and rapidly	(Gassmann and Keupp, 2007)
Having tight control over production processes due to close management involvement	(Levy and Powell, 1998)
Productive	(Beck et al., 2005)
Knowledge creating	(Egbu et al., 2005, Levy et al., 2003)
Fast learning and adapting routines and strategy	(Axelson, 2005)
Great potential to adapt new production methods	
Creating astute alliances, networking	(Dijk et al., 1997; Massa and Testa, 2008; Partanen et al., 2008; Karaev et al., 2007; Kearney and Abdul-Nour, 2004)

operations.

The major characteristics of SMEs

To have a better understanding of SMEs behavior, a brief knowledge of the characteristics of SMEs is a must and therefore, the major characteristics of SMEs are listed in Tables 1 and 2 (These are for all types of SMEs (generalizations) and not all may hold true for every SME's.). SMEs are not scaled-down versions of large companies. There are different characteristics that distinguish them from large corporations and that can, of course, change across different countries and cultures. SMEs are generally independent, multi-tasking, cash-limited and owner-based actively managed by the owners, highly personalized and informal structured, largely localized enterprises in their area of operations that are largely dependent on internal sources to the growth of finance (Perrini et al., 2007).

Table 2. Some of the major disadvantages of SMEs.

Disadvantages	References
Scarce resources and manpower	(Wang and Chou, 2008; Pullen et al., 2008; Hanna and Walsh, 2002; Lu and Beamish, 2006; Nieto and Fern´andez, 2005; Axelson, 2007; Deros et al., 2006; Partanen et al., 2008; Caputo et al., 2002; Abdul-Nour et al., 1999; Kearney and Abdul-Nour, 2004; Bodorick et al., 2002; Sarosa, 2007; Jansson and Sandberg, 2008; Kim et al., 2008a; Yusuff et al., 2005; Laforet, 2008)
limited degree of information technology (IT) implementation	(Wang and Chou, 2008; Sharma and Bhagwat, 2006; Egbu et al., 2005; Lin et al., 2007; Eikebrokk and Olsen, 2007; Corso et al., 2003; Sarosa and Zowghi, 2003)
Weak at converting R&D into effective innovation	(O'Regan et al., 2006a; O'Regan et al., 2006b)
Lacking some of the essential resources for innovation (poor innovative capabilities)	(Dickson and Hadjimanolis, 1998; Sharma and Bhagwat, 2006; Lee and Ging, 2007; Rolfo and Calabrese, 2003; Massa and Testa, 2008; Hausman, 2005; Tiwari and Buse, 2007; Singh et al., 2008)
Severe resource limitations in R&D	
Strategy is based on low price, high quality offerings, rather than new product innovations	(Hobday et al., 2004)
Not having formal R&D activities	(Adams et al., 2006; Bougrain and Haudeville, 2002)
Strategy formulation on the basis of what available, lack a long run perspective	(Gomez and Simpson, 2007; Lindman, 2002; Yusuff et al., 2005)
Reliance on the small number of customers, and operating in limited markets. Reactive and fire fighting mentality.	(Sharma and Bhagwat, 2006)
Rely on outdated technology, labor-intensive and traditional management practices	(Deros et al., 2006; Beck et al., 2005; Caputo et al., 2002)
Lagging in the export, lack the resources necessary to enter foreign markets	(Mahajar et al., 2006; Jansson and Sandberg, 2008)
Lack of formal competitor analysis, data collection during NPD processes.	(Woodcock et al., 2000)
Absolute size, fewer technological assets	(Narula, 2004)
lack of the industrial engineers or right kind of manpower to apply various statistical and managerial methods or tools	(Ahmed and Hassan, 2003)

NEW PRODUCT DEVELOPMENT (NPD)

Product life cycle of manufactured goods falls shorter every year. Today, leading-edge firms can exploit global asset configurations to customize existing products and services and they also have the ability to combine their resources with an expanding knowledge base to create a continuous stream of new products and services (Miles et al., 2000). With the needs to respond quickly to dynamic customer needs, increased complexity of product design and rapidly changing technologies, selecting the right set of NPD is critical to a company's long-term success (Chen et al., 2008a). Furthermore, combination of factors such as ever changing market needs and expectations, uneven competition and emerging technologies and among others, challenging industrial companies to continuously increase the rate of new products to the market to fulfill all these needs (Sorli et al., 2006). Because of the above circumstances, product innovations are central in securing a firm's competitive advantage from international markets (Jeong, 2003). NPD is vital and needs to be developed both innovatively and steadily (Chen et al., 2008a).

New product development process

Today's uncertain and dynamic environment presents a

fundamental challenge to the NPD process of the future (MacCormack et al., 2001). NPD is a multi-dimensional process and involves multiple activities (Ozer, 2000). Kusar al. (2004) summarized different stages of a NPD, where in earlier stages, the objective is to make a preliminary market analysis, business and technical assessment, whereas at the later stages a new product is designed and developed. The stages could be seen as:

1. Definition of goals (goals of the product development process)
2. Feasibility study (term plan, financial plan, pre-calculation, goals of market)
3. Development (first draft and structure of the product and parts, product planning and its control processes)
4. Design (design of components, drawing of parts, bills of material)

NPD and SMEs

New product development is of high importance for both large and small and medium-sized organizations (Pullen et al., 2008). To cope up with force of globalization, producers have to continuously innovate and upgrade the quality of their existing products (Acs and Preston, 1997). In these circumstances, companies offer their customers the right products with features and quality, at the right time and at the right price can expect market success (Kusar et al., 2004). A multidisciplinary approach is needed to be successful in launching new products and managing daily operations (Flores, 2006). In the NPD context, teams developing new products in the turbulent environments face quick depreciation of technology and market knowledge because of rapidly changing customer needs, wants and desires, and technological know-how (Akgun et al., 2007).

There are quite a few researchers done to assess NPD performance. For instance, (Cooper et al., 2004) identify various measures of NPD performance at the program and project levels. Measures of performing the entire NPD program include the percentage of business profits from new products, return on investment on R&D spending, and the success rate of launched/developed products. All of these measures show that NPD brings positive growths. With some exceptions, papers addressing the problems and tools needed for implementing NPD in small organizations are lacking (Toni and Nassimbeni, 2003).

NPD and dispersed team

Different products may need different processes. A new product idea needs to be conceived, selected, developed, tested and finally launched to the market (Martinez-Sanchez et al., 2006). The specialized skills and talents needed for developing new products often remain and develop locally in pockets of excellence around the company or even around the world. Firms, therefore, have no choice but to access such dispersed knowledge and skills to diffuse their new products (Kratzer et al., 2005). Virtualization in NPD has recently started to make sober headway due to developments in technology; virtuality in NPD is now technically possible (Leenders et al., 2003). Automotive original equipment manufacturers (OEMs) have formed partnerships with suppliers to take advantage of their technological expertise in development, design and manufacturing (Wagner and Hoegl, 2006). As product development becomes more complex, they also have to collaborate more closely than in the past. These kinds of collaborations almost always involve individuals from different locations, so virtual team-working supported by IT, offers notable potential benefits (Anderson et al., 2007). May and Carter (2001) in their case study on virtual team-working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them to get benefits such as better quality, reduced costs and reduced time-to-market (between 20 to 50%) for the new product.

NPD and virtuality

New product development (NPD) has long been recognized as one of the corporate core functions (Huang et al., 2004). The rate of market and technological changes has accelerated in the past years and this turbulent environment requires new methods and techniques to bring the successful new products to the marketplace (González and Palacios, 2002). The world market requires short product development times (Starbek and Grum, 2002). Therefore, to successfully and efficiently capture all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams (Precup et al., 2006). NPD needs collaborated with new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough et al., 2001; Ozer, 2000) and NPD teams are necessary in most businesses (Leenders et al., 2003).

In addition, the pressure of global competition put companies under intense pressures to build critical mass, reach new markets and plug skill gaps, NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements (Cummings and Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001).

Table 3. Covering lack of SMEs by virtual teams.

Disadvantage of SMEs	Advantage of virtual team
Scarce resources and manpower (Wang and Chou, 2008; Kim et al., 2008, Pullen et al., 2008; Hanna and Walsh, 2002; Lu and Beamish, 2006; Nieto and Fern´andez, 2005; Axelson, 2007; Deros et al., 2006; Laforet, 2008)	Able to tap selectively into the centre of excellence, using the best talent regardless of location (Criscuolo, 2005; Cascio, 2000; Samarah et al., 2007; Fuller et al., 2006; Furst et al., 2004). Reducing relocation time and costs, reduced travel costs (McDonough et al., 2001; Rice et al., 2007; Bergiel et al., 2008; Cascio, 2000; Fuller et al., 2006; Kankanhalli et al., 2006).
	Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise, be reduced if the time-to market is quicker (Rabelo and Jr. , 2005)] (May and Carter, 2001; Sorli et al., 2006; Kankanhalli et al., 2006; Chen, 2008; Shachaf, 2008; Kusar et al., 2004; Ge and Hu, 2008; Mulebeke and Zheng, 2006)
Lacking some of the essential resources for innovation, Severe resource limitations in R&D (Dickson and Hadjimanolis, 1998; Sharma and Bhagwat, 2006; Lee and Ging, 2007, Rolfo and Calabrese, 2003, Massa and Testa, 2008, Hausman, 2005)	Organizations seeking to leverage scarce resources across geographic and other boundaries (Munkvold and Zigurs, 2007)
	More effective R&D continuation decisions (Cummings and Teng, 2003).
	It can manage the development and commercialization tasks well (Chesbrough and Teece, 2002)
Not having formal R&D activities (Adams et al., 2006) limited degree of information technology (IT) implementation (Wang and Chou, 2008; Sharma and Bhagwat, 2006; Egbu et al., 2005; Lin et al., 2007; Eikebrokk and Olsen, 2007; Corso et al., 2003)	Sharing knowledge, experiences (Rosen et al., 2007; Zakaria et al., 2004; Furst et al., 2004)
Weak at converting R&D into effective innovation (O'Regan et al., 2006a; O'Regan et al., 2006b)	Easing transnational innovation (Gassmann and Von Zedtwitz, 2003b)
	Higher team effectiveness and efficiency (May and Carter, 2001, Shachaf and Hara, 2005)
Strategy formulation based on what is available (Gomez and Simpson, 2007)	Respond quickly to changing business environments (Bergiel et al., 2008; Mulebeke and Zheng, 2006)
Rely on outdated technology, labor-intensive and traditional management practices (Deros et al., 2006; Beck et al., 2005)	Most effective in deciding (Hossain and Wigand, 2004)
	Provide organizations with a unprecedented level of flexibility and responsiveness (Powell et al., 2004, Hunsaker and Hunsaker, 2008, Chen, 2008)
Lagging in the export (Mahajar et al., 2006)	Provide a vehicle for global collaboration and coordination of R&D-related activities (Paul et al., 2005)

Web base collaboration

The Internet, incorporating computers and multimedia have provided potential for remote integration and collaboration in business and manufacturing applications (Lan et al., 2004). A web-based collaborative product design platform enables geographically dispersed authorized users to have access to the company's product data such as product drawing files stored at appointed servers and carry out product design work simultaneously and collaboratively in any operating systems (Zhan et al., 2003). It is however, hard to allocate funding and to design infrastructures and software to support virtual team-working (Chudoba et al., 2005). Despite the widespread use of computers for personal applications, few programming frameworks exist for creating synchronous collaborative applications (Holloway and Julien, 2006). An integrated system can effectively support a dispersed team (Li et al., 2004).

SMEs: VIRTUAL R&D TEAMS AND NPD

A global market needs a short product development cycle; therefore SMEs are also forced into shifting from sequential to concurrent product development. Virtual teams are dramatically influencing organizations and doing virtual R&D for SMEs is not a choice but a duty to reduce the time-to-market in the intensively competitive market environment.

With the findings of Gassmann and Keupp (2007) advantages of virtual teams for SMEs are extracted and illustrated in Table 3. Managers of SMEs should invest less in tangible assets, but more in those areas that will directly produce their future competitive advantage such as R&D. Therefore, managers of SMEs should recognize that virtual teams in NPD are essential in modern organizations.

Simple transmission of information between new product teams' members is not adequate; the virtual R

and D team should also constructively interact within each team. Managers should have an action plan for bringing the idea to practice. For a successful adoption of virtual teams to develop a new product, relevant impact on the success factors of NPD should be considered.

CONCLUSION

This paper is provided a comprehensive literature review covering the topics of SMEs, virtual R&D teams and NPD. Web service technology, although now is very popular but still not matured enough, so dealing with it can produce new findings. Currently, from the point of the topic, it suffers from the limit of coverage in almost all major publications. There are still notable gaps in virtual R&D team efforts and effects on new product development within SMEs. A comprehensive empirical study would now be important. Such a study would provide an assessment on patterns, practices, technology or types of activities that should be carried out by R&D virtual teams in SME's to realize more effective NPD niches. It can also detail with the methods being used and their effectiveness as well as preconditions do SMEs must consider for virtual R&D teams. From the application view, it can look into the transition from a traditional R&D structure to the distributed R&D in SMEs. Extensive research is needed to understand the different characteristics of successful virtual R&D teams for NPD in SMEs. We believe, this study provides a further step into the benefits and problems arise in this direction. Future research shall be intending at shifting away from exploring NPD, SMEs and virtual R&D teams separately to the formation and development of a collaborative tools which can support a dispersed team effectively. R&D collaboration can be used as an optional strategy for the knowledge sharing and easing the development of new products, services or processes, among SMEs, which are suffering from lack of resources.

A review of the literature shows the factors that impact on the effectiveness of virtual teams for new product development, are still ambiguous. Effective management can help a virtual R&D teams in SMEs to overcome the constraints imposed by applying virtual R&D teams. Future research would now seem to be essential for developing a comprehensive study (combining survey with case study) in different aspects of virtual teams for NPD. Such a study needs to propose a model for virtual collaboration during the NPD process. While most of the research activities relevant to SMEs do not encourage and support international research cooperation and technology transfer, such as virtual teams will be potentially worthwhile. Similar potential advantages have been listed in Table 1. Therefore, it is vital to bridge this gap and unlock growth opportunities for SMEs through research and help them carry out or outsource research to develop new technology - based products, processes and services, exploit research results, acquire technological know-how and train their employees to incorporate development processes. Setting-up a new pattern has a major obstacle ahead. Therefore, setting-up an infrastructure for virtual R&D team in SMEs still needs many engineering efforts, especially designing a proper Web base collaborative system.

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Scientific Research and Essays Vol. 7(21), pp. 1971-1985, 7 June, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.1005
ISSN 1992-2248 © 2012 Academic Journals

Full Length Research Paper

Effective virtual teams for new product development

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Accepted March 29, 2012

At present, the existing literature shows that the factors which influence the effectiveness of virtual teams for new product development are still ambiguous. To address this problem, a research design was developed, which includes detailed literature review, preliminary model and field survey. From literature review, the factors which influence the effectiveness of virtual teams are identified and these factors are modified using a field survey. The relationship between knowledge workers (people), process and technology in virtual teams is explored in this study. The results of the study suggest that technology and process are tightly correlated and need to be considered early in virtual teams. The use of software as a service, web solution, report generator and tracking system should be incorporated for effectiveness virtual teams.

Key words: Virtual teams, collaboration, questionnaires, communication, information, integration, performance, success, cross-functional teams, product development.

INTRODUCTION

Nowadays, virtual teams enable work to be carried out over computer networks and reduce the need for teams to be collocated. Virtual teams are defined as "small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, mainly with electronic information and communication technologies to carry out one or more organization tasks" (Ale Ebrahim et al., 2009b). The statement "We are becoming more virtual all the time!" is often heard in many global corporations today (Chudoba et al., 2005). New product development (NPD) is widely recognized as a key to corporate prosperity (Lam et al., 2007). Different products may need different processes. A new product idea needs to be conceived, selected, developed, tested and launched to the market (Martinez-Sanchez et al., 2006). The specialized skills and talents required for the development of new products often reside (and develop) locally in pockets of excellence around the company or even around the world. Therefore, firms have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). Consequently, firms are faced with the problem that the internal development of all technologies required for new products and processes are difficult or impossible. Firms must increasingly receive technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make a serious headway due to developments in technology - virtuality in NPD is now technically possible (Leenders et al., 2003). Supply chains need to collaborate more closely compared with the past as prodcu development becomes more complex. These collaborations almost always involve individuals from different locations, and therefore, virtual teamwork supported by information technology (IT) offer notable potential benefits (Anderson et al., 2007). Although the use of the internet in NPD has received considerable attention in the literature, little is known regarding collaborative tools and effective virtual

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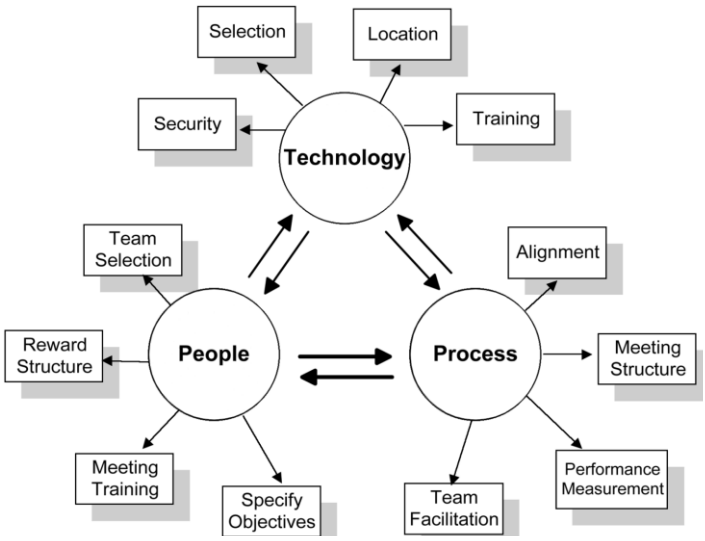

Figure 1. Model for effective virtual teamwork (Source (Bal and Gundry, 1999)).

teams for NPD (Ale Ebrahim et al., 2009a).

THE NEED FOR EFFECTIVE VIRTUAL TEAMS

A review of the literature reveals that the factors which influence the effectiveness of virtual teams are still ambiguous (Ale Ebrahim et al., 2009d). One of the notable challenges for effective virtual teams is ensuring good communication amongst all members of the distributed teams (Anderson et al., 2007). Jarvenpaa and Leidner (1999) found that regular and timely communication feedback is a key to building trust and commitment in distributed teams. A study by Lin et al. (2008) suggested that social dimensional factors need to be considered early during the virtual team creation process, and are critical to the effectiveness of the team. Communication is a tool that directly influences the social dimensions of the team, which improves team performance and has a positive impact on satisfaction within the virtual team.

For teams moving from collocation to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams (Kirkman et al., 2002). Despite weak ties between virtual team members, ensuring lateral communication may be adequate for effective virtual team performance. In terms of implementation, lateral communication in both virtual context and composition teams can be increased by reducing the hierarchical structure of the team (that is, a flatter reporting structure and/or decentralization) and the use of computer-mediated communication tools (Wong and Burton, 2000).

Malhotra and Majchrzak's (2004) study of 54 effective virtual teams found that creating a state of shared understanding about goals and objectives, task requirements and interdependencies, roles and responsibilities, and member expertise had a positive effect on output quality. Hertel et al. (2005) collected effectiveness ratings from team managers both at the individual team levels. The results of the field study showed good reliability of task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara (2005) proposed four dimensions of effective virtual team leadership:

1. Communication: the leader provides continuous feedback, engages in regular and prompt communication and clarifies tasks.
2. Understanding: the leader is sensitive to the members' schedules, appreciates their opinions and suggestions, cares about their problems, gets to know them and expresses a personal interest in them.
3. Role clarity: the leader clearly defines responsibilities of all members, exercises authority, and mentors virtual team members.
4. Leadership attitude: the leader is assertive yet not too "bossy," caring, relates to members at their own levels, and upholds a consistent attitude over the life of the project.

From observations and interviews, Bal et al. (2001b, 1999) identified 12 elements for effective virtual teamwork, as illustrated in Figure 1. The Bal and Gundry (2001b, 1999) model was used as the basic framework in this paper.

Table 1. Tools for virtual teams.

Tool	Examples	Uses and Advantages	Immediacy	Sensory Modes
Instant Messaging and Chat	• Yahoo Messenger • MSN Messenger • AOL Instant Messenger • Skype	• Instant interaction • Less intrusive than a phone call • View who is available • Low cost • Low setup effort	• Synchronous or asynchronous	• Visual • Text and limited graphics
Groupware / Shared Services	• Lotus Notes • Microsoft Exchange • Novell Groupwise	• Calendars • Contact Lists • Arrange meetings • Cost and setup effort vary	• Asynchronous	• Visual
Remote Access and Control	• NetMeeting • WebEx • Remote Desktop • pcAnywhere	• User controls a PC without being on-site • Cost varies • Setup varies	• Synchronous	• Visual • Audio • Tactile
Web Conferencing	• NetMeeting • WebEx • Meeting Space • GoToMeeting	• Live audio • Dynamic video • Whiteboard • Application sharing • Moderate cost and setup effort	• Synchronous	• Visual • Unlimited graphics • Optional audio
File Transfer	• File Transfer Protocol (FTP) • Collaborative Websites • Intranets	• Share files of any type • Cost varies • Moderate setup effort	• Asynchronous	• Varies with file content
Email	• Many vendors and free applications	• Send messages or files • Cost and setup effort vary	• Asynchronous	• Visual • Audio in attached files
Telephone	• “Plain Old Telephone Service” (POTS) • Voice Over Internet Protocol (VOIP)	• Direct calls • Conference calls • Cost varies • Low setup effort	• Synchronous • Asynchronous for voice mail	• Audio

Adopted from Thissen et al. (2007).

Virtual teamwork: Technology point of view

Selection

A simple transmission of information from point A to point B is insufficient as the virtual environment presents significant challenges for effective communication (Walvoord et al., 2008). Being equipped with even the most advanced technology is inadequate to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be present for a team to succeed in the virtual world (Lurey and Raisinghani, 2001). Information richness seems to be the most important criterion for technology selection and the greatest impediment to the effectiveness of virtual teams is the implementation of technology (Mikkola et al., 2005). Virtual teams are technology-mediated groups of people from different disciplines that work on common tasks (Dekker et al., 2008). Hence, the way the technology is implemented appears to be a factor which makes a virtual team’s outcome more or less likely successful (Anderson et al., 2007). The matrix in Table 1 assists the virtual team facilitator in choosing the suitable technology based upon the purpose of the meeting.

Location

Virtual teams enable organizations to access the most qualified individuals for a particular job regardless of their locations and provide greater flexibility to individuals working from home or on the road (Bell and Kozlowski, 2002). Table 2 shows the relationship between tools, time and space in virtual teams.

Training

Suggestions for training remote managers and virtual

Table 2. Time /Space matrix.

	Same space	Different space
Same time Synchronous	Face-to-face meeting, Brainstorming, Vote, PC and projector Electronic white board, GDSS, Chat	Chat, Tele-conference, Video-conference, Liaison satellite, Audio-conference, Shared white board, Shared application
Different time Asynchronous	Team room, Document management system, Discussion forum, E-mail, Workflow, Project management	E-mail, Workflow, Document sharing , Discussion forum, Group agenda Cooperative hypertext and organizational memory, Version control Meeting scheduler

Adapted from Bouchard and Cassivi (2004).

team development can be found in (Hertel et al., 2005). The results of Anderson et al.'s (2007) systematic lab study confirmed many observations, including explicit preparation and training for virtual teams as a way of working collaboratively. In the case of computer collective efficacy, Fuller et al. (2006) indicated that computer training which is related to more advanced skills sets may be useful in building virtual team efficacy. Hertel et al. (2005) suggested that training leads to increased cohesiveness and team satisfaction.

Security

Since virtual teamwork involves exchanging and manipulating sensitive information and data via the Internet, security is always an important issue of concern (Bal and Teo, 2001b). Team leaders should identify the special technological and security level needs of the virtual team and their team members (Hunsaker and Hunsaker, 2008).

Virtual teamwork: People point of view

Team selection

Team selection is one of the key factors which distinguish successful teams from unsuccessful ones (Ale Ebrahim et al., 2009d). Virtual teams can be designed to include people who are most suited for a particular project (Bell and Kozlowski, 2002). In this manner, the project will be clearly defined, and the outcome priorities and supportive team climate will be established. Selection of members with the necessary skills is crucial for virtual teams (Hunsaker and Hunsaker, 2008). Selection of virtual team members is particularly difficult due to the geographical and organizational separation involved (Bal and Gundry, 1999).

Reward structure

Developing a fair and motivating reward system is another significant issue at the beginning of virtual teamwork (Bal and Teo, 2001a; Hertel et al., 2005). Virtual team performance must be recognized and rewarded (Bal and Gundry, 1999). Lurey and Raisinghani (2001) found that reward systems ranked strongly among the external support mechanisms for virtual teams in a survey to determine the factors that contribute to the success of a virtual team.

Meeting training

Comparing teams with little and extensive training, Bal and Gundry (1999) noted a significant drop in performance as both teams went live using the system. However, the latter then improved its performance at a faster rate than the former. Training is a key aspect which cannot be neglected in team building. Virtual team members require different types of training compared to ordinary teams. The training includes self-managing skills, communication and meeting training, project management skills, technology training, et cetera (Bal and Teo, 2001b).

Specify an objective

While direct leadership strategies are possible in conventional teams, members of virtual teams may be managed more effectively by empowerment and by delegating managerial functions to the members (Hertel et al., 2005). Such an approach changes the role of a team manager from traditional controlling into more coaching and moderating functions (Kayworth and Leidner, 2002).

Virtual team leaders should identify commonalities among members early on, while focusing the team on achieving key performance objectives (Ale Ebrahim et al., 2009d).

Virtual teamwork: Process point of view

Alignment

The company's processes need to be re-aligned with the

capabilities of virtual teams, unlike face-to-face teams.

This involves an understanding of virtual team processes and existing processes (Bal and Gundry, 1999). However, the key elements in knowledge sharing are hardware, software as well as the ability and willingness of team members to actively participate in the knowledge sharing process (Rosen et al., 2007).

Meeting structure

Proximity enables team members to engage in informal work (Furst et al., 2004). Virtual team members are more likely to treat one another formally, and are less likely to reciprocate requests from one another (Wong and Burton, 2000). Shin (2005) argued that lack of physical interactions and informal relationships decrease the cohesiveness of virtual teams. Formal practices and routines designed to structure tasks formally were reported to lead to higher quality output of virtual teams (Massey et al., 2003). The physical absence of a formal leader exacerbates the lack of extrinsic motivation (Kayworth and Leidner, 2002). For virtual teams which rarely meet face-to-face, team leaders often have no choice but to impose a formal team structure. Synchronous written documents assist virtual teams to overcome challenges associated with spoken language, and this enables teams to overcome challenges associated with asynchronous and lean written communication (Shachaf, 2008).

Performance measurement

Kirkman and Rosen et al. (2004) studied the performance of virtual teams and showed a positive correlation between empowerment and virtual team performance. High-performance teams are differentiated by passionate dedication to goals, emotional bonding among team members and identification, and a balance between unity and respect for individual differences (Ale Ebrahim et al., 2009d).

Team facilitation

Team members must have crystal clear rules and responsibilities. The rule should be accountable and visible. Virtual team members may feel less accountable for results due to lack of visibility circumstances. Therefore, explicit facilitation of virtual teams is of extreme importance for teamwork. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability (Massey et al., 2003).

NEW PRODUCT DEVELOPMENT AND VIRTUALITY

Product development is defined by different researchers in slightly different ways, but generally it is the process that covers product design, production system design and product introduction processes and start of production (Johansen, 2005). New product development (NPD) has long been recognized as one of the corporate core functions (Huang et al., 2004). The rate of market and technological changes has accelerated in the past years and this turbulent environment needs new methods to bring successful new products to the marketplace (González and Palacios, 2002). This is particularly true for companies with short product life cycles, whereby it is important to develop new products and new product platforms quickly and safely, which fulfill reasonable demands on quality, performance and cost (Ottosson, 2004). The world market requires short product development times (Starbek and Grum, 2002). Therefore, in order to successfully and efficiently obtain all the experience needed for developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams (Precup et al., 2006). Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Badrinarayanan and Arnett, 2008; Jacobsa et al., 2005; Schmidt et al., 2001). New product development requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough et al., 2001;Ozer, 2000). NPD teams are necessary in most businesses (Leenders et al., 2003). In addition, in the haste of global competition, companies faced increasing pressure to build critical mass, reach new markets and plug skill gaps. NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements (Cummings and Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001; Ale Ebrahim et al., 2010). The use of virtual teams for new product development is rapidly growing and in which organizations can rely on to sustain competitive advantage (Taifi, 2007). Hence, virtual teams provide valuable input for new product development (Ale Ebrahim et al., 2009c).

PRIMARY MODELS AND HYPOTHESES

In this study, a new primary model is adapted from Bal and Gundry (2001b, 1999), with respect to the requirements of the company in determining the

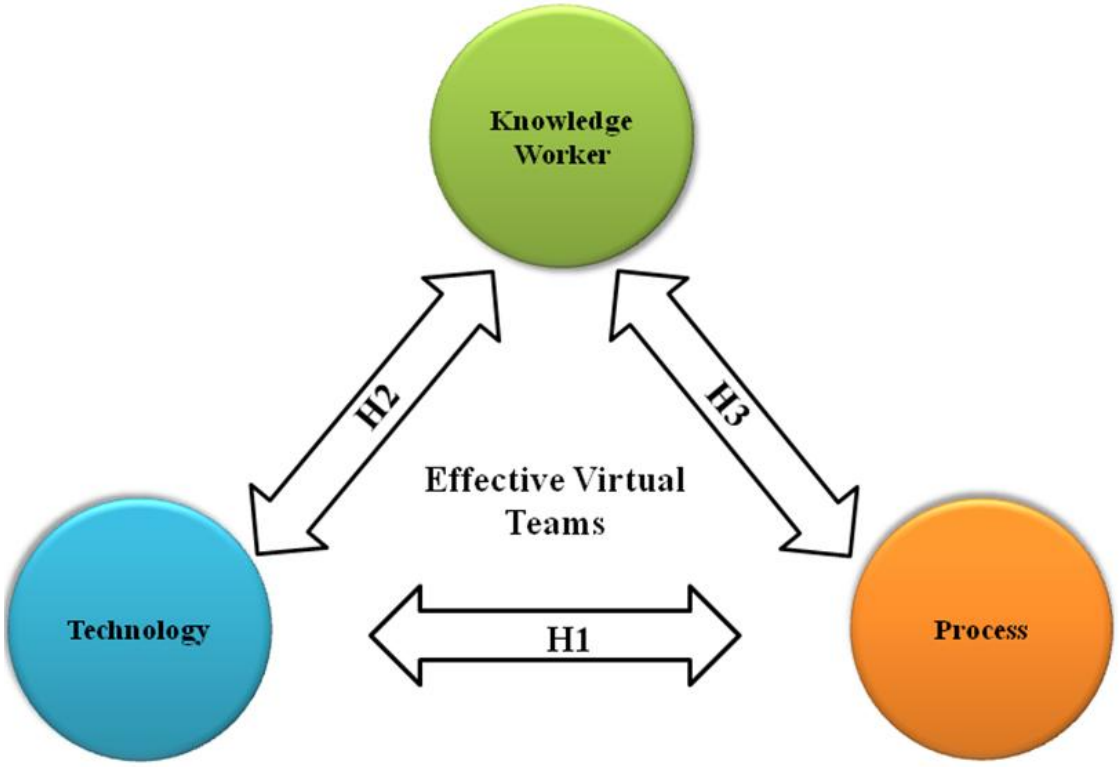

Figure 2. Preliminary model for evaluating the effectiveness of virtual teams.

appropriate design tools and methods for an effective new product development in virtual teams (Figure 2).

Hypotheses

From a review of the existing literature, it is evident that there remains a gap with respect to the requirements of the company in determining the appropriate design tools and methods for effective new product development in virtual teams. This research proposes the following hypotheses in order to fulfill the requirements:

H_1: Technology is positively correlated to Process in virtual teams.
H_2: Technology is positively correlated to Knowledge Workers in virtual teams.
H_3: Process and Knowledge Workers are positively correlated in virtual teams.
H_4: There is an insignificant difference between the origins of virtual teams.

METHODOLOGY

To test the hypotheses, a Web-based survey was carried out in a random sample of small and medium enterprises in Malaysian and Iranian manufacturers. A survey is developed for data collection, whereby a Likert scale from 1 to 5 is used. This scale provides respondents with a series of attitude dimensions. For each dimension, the respondent is asked whether, and how strongly, they agree or disagree to each dimension using a point rating scale. The questionnaire is e-mailed to the Managing Director, R&D Manager, New Product Development Manager, Project and Design Manager and appropriate personnel who are most familiar with R&D activities within the firm. The rapid expansion of Internet users has given Web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002; Ebrahim et al., 2010). The findings of Denscombe (2006) encouraged social researchers to use Web-based questionnaires with confidence. The data produced by Web-based questionnaires is equivalent to that produced by paper-based questionnaires. Other authors highlighted the data provided by Internet methods are of at least as good quality as those provided by traditional paper-and-pencil methods (Gosling et al., 2004; Deutskens et al., 2006). Invitation e-mails are sent to each respondent, reaching 1500 valid e-mail accounts, with reminders following one month later. 240 enterprises submit responses, giving an overall response rate of 12%. Table 3 presents the respondents' demographics upon deduction of missing data. The survey is limited to the sample size and population in the specified regions.

RESULTS AND ANALYSIS

For reliability analysis, Cronbach's Alpha (Cronbach, 1951) is employed to measure the internal consistency of each construct. A reliability test is carried out to ensure that the research findings have the ability to produce

Table 3. Frequency Distributions of Demographic Variables (N=240).

Variable	Frequency distribution N (%)	
Gender	Male	202 (85.6)
	Female	34 (14.4)
Country	Iran	136 (56.7)
	Malaysia	74 (30.8)
	Others (Developing)	15 (6.2)
	Others (Developed)	15 (6.2)
Age group	Up to 21	2 (0.9)
	21-34	103 (44.6)
	35-49	101 (43.7)
	50-64	23 (10.0)
	Over 65	2 (0.9)
Job Roles	Managing director	51 (22.7)
	R&D Manager	25 (11.1)
	New Product Development Manager	27 (12.0)
	Project Manager	43 (19.1)
	Design manager	7 (3.1)
	Others	72 (32.0)
Main Business	Automotive/vehicle and components	89 (37.1)
	Electronic products and components	30 (12.5)
	Fabricated metal products	13 (5.4)
	Electrical machinery, apparatuses, appliances, or supplies	12 (5.0)
	Machinery/ Industrial equipment	9 (3.8)
	Home appliances	12 (5.0)
	Pharmaceutical or Chemical products (including cosmetics, paints)	4 (1.7)
	Paper products	4 (1.7)
	Plastic products	3 (1.2)
	Food and Food packaging	1 (0.4)
	Instrumentation equipment	4 (1.7)
	Textile	2 (0.8)
	Oil and Gas	11 (4.6)
	Education	14 (5.8)
	Others	32 (13.3)

consistent results. From Table 4, all items having a Cronbach's α greater than 0.6 are included in the analysis, while the rest are omitted from the analysis. In general, the reliability of the questionnaire's instruments is acceptable.

The Bartlett's Chi-square test of sphericity and Kaiser-Meyer-Olkin (KMO) is used to measure sampling adequacy in order to conclude whether the partial correlation of the knowledge workers and variables are small (Fathian et al., 2008). Table 5 summarizes the results of KMO, in which the value is 0.878. The significant value for Bartlett's test is less than 0.05, and the results indicate that there is good correlation.

An exploratory factor analysis is performed on eight knowledge worker factors after removing Pe1, Pe5 and Pe11, which have a Cronbach's α of less than 0.6 using a Principle Component Analysis with a Varimax Rotation and an Eigenvalue of 1 as the cut-off point (Akgün et al., 2008) and an absolute value of a loading greater than 0.5 (Fathian et al., 2008). Factor loading shows that only one component can be extracted. Therefore, all eight items in knowledge workers can be grouped into a single factor.

The same procedure is performed on process and technology factors. The items and their factor loadings

Table 4. Summary of the final measures and reliabilities.

Factor and variable name		Items	Mean*	Std. Deviation	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Knowledge worker (N=218)	Pe1	Working together	4.037	1.029	0.560	0.872
	Pe2	Interactions from inside	3.995	0.912	0.641	0.867
	Pe3	Interactions from outside	3.824	1.001	0.634	0.867
	Pe4	Interactions with colleagues	3.982	0.991	0.649	0.866
	Pe5	Online training and e-learning	3.401	1.143	0.597	0.87
	Pe6	Consulting service	3.472	0.998	0.624	0.868
	Pe7	Collaborating and making decisions with co-workers or suppliers	3.863	0.943	0.642	0.867
	Pe8	Facilitates cooperation between employees	3.876	0.917	0.651	0.867
	Pe9	Facilitates introduction of new employees	3.553	1.079	0.654	0.866
	Pe10	Facilitates the management of NPD project	3.706	1.014	0.654	0.866
	Pe11	Is used by competitors	3.106	1.238	0.301	0.893
Process (N=211)	Pr1	Project control (such as Intranet based project status tracking system)	3.64	1.101	0.650	0.928
	Pr2	Project reporting system (such as MS-Project reporting system)	3.82	1.026	0.666	0.927
	Pr3	Making business together	3.648	0.943	0.627	0.928
	Pr4	Reduce traveling time and cost	3.862	1.024	0.722	0.925
	Pr5	Reduce the number of working hours needed to solve the task	3.827	1.008	0.725	0.925
	Pr6	Collaborative solutions	3.701	0.916	0.694	0.926
	Pr7	Facilitates data collection in new product development project	3.813	0.952	0.744	0.924
	Pr8	Interaction with customers for gathering new product features	3.83	0.973	0.674	0.926
	Pr9	Provide quantitative answer	3.384	0.985	0.664	0.927
	Pr10	Generate an easy and interpretable answer	3.333	0.981	0.642	0.927
	Pr11	Ease of generating reports	3.678	1.028	0.740	0.924
	Pr12	Ease of data entry	3.775	0.937	0.737	0.924
	Pr13	Ability to accommodate multiple users	3.905	1.019	0.667	0.927
Technology (N=218)	Te1	Use internet and electronic mail	4.202	0.986	0.528	0.945
	Te2	Online meeting on need basis	3.535	1.13	0.764	0.941
	Te3	Web conferencing	3.381	1.17	0.778	0.941
	Te4	Seminar on the Web	3.134	1.172	0.742	0.942
	Te5	Shared work spaces	3.507	1.063	0.749	0.942
	Te6	Video conferencing	3.172	1.161	0.737	0.942
	Te7	Audio conferencing	3.221	1.146	0.735	0.942
	Te8	Online presentations	3.453	1.107	0.809	0.941
	Te9	Share documents (off-line)	3.601	1.075	0.637	0.944
	Te10	Share what's on your computer desktop with people in other locations (in real time)	3.196	1.206	0.577	0.945
	Te11	Do not install engineering software (get service through web browser)	3.179	1.211	0.590	0.945
	Te12	Access service from any computer (in Network)	3.542	1.041	0.688	0.943
	Te13	Standard phone service and hybrid services	3.576	1.07	0.511	0.946
	Te14	Access shared files anytime, from any computer	3.686	1.01	0.625	0.944
	Te15	Web database	3.649	0.995	0.704	0.943
	Te16	Provide instant collaboration	3.595	1.037	0.654	0.943

Table 4. Contd.

Te17	Software as a service (eliminating the need to install and run the application on the own computer)	3.531	1.07	0.666	0.943
Te18	Virtual research center for product development	3.455	1.078	0.681	0.943
Te19	Can be integrated/compatible with the other tools and systems	3.688	1.139	0.613	0.944

*Frequency values - 1: Not important; 2: Slightly important; 3: Important; 4: Quite important; 5: Extremely important.

Table 5. KMO and Bartlett's Test results.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0. 878**
Bartlett's Test of Sphericity	Approx. Chi-Square	679.744
	df	28
	Sig.	0.000

Table 6. Factor analysis results on 13 process items.

Component	**Initial eigenvalues**			**Rotation sums of squared loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	7.158	55.062	55.062	4.255	32.733	32.733
2	1.126	8.662	63.724	4.029	30.991	63.724
3	0.951	7.314	71.039			
4	0.737	5.670	76.708			
5	0.544	4.185	80.893			
6	0.461	3.544	84.437			
7	0.445	3.422	87.859			
8	0.415	3.192	91.051			
9	0.333	2.558	93.609			
10	0.304	2.338	95.947			
11	0.222	1.707	97.654			
12	0.173	1.331	98.985			
13	0.132	1.015	100.000			

Extraction method: Principal Component Analysis.

after Exploratory Factor Analysis, Eigenvalue, and percentage of variance, are shown in Tables 6, 7, 8 and 9, respectively The 13 process items and 15 technology items are divided into two different groups, which have an Eigenvalue greater than one.

The confirmed factors are then identified based on conciseness, without losing clarity of meaning. Upon extraction of the factors, the items with higher loadings are considered more important and have greater influence on the name of selected reduced factors. The names and contents of the two derived factors on process items are:

1. Factor FPr1: This consists of Items Pr8 through Pr13, which are *"Interact with customers for gathering new product features"*, *"Provide quantitative answer"*, *"Generate an easy and interpretable answer"*, *"Ease of generating reports"*, *"Ease of data entry"* and *"Ability to*

Table 7. Rotated Component Matrix sorted by size for 13 process items.

Items	Component	
	1	2
Pr11	0.783	0.326
Pr9	0.781	0.225
Pr10	0.767	0.213
Pr12	0.751	0.350
Pr8	0.724	0.302
Pr13	0.576	0.443
Pr1	0.202	0.804
Pr2	0.229	0.792
Pr3	0.248	0.724
Pr6	0.352	0.711
Pr5	0.484	0.620
Pr4	0.482	0.614
Pr7	0.527	0.594

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Table 7. Factor analysis results on 15 technology items.

Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.471	56.471	56.471	5.581	37.205	37.205
2	1.681	11.207	67.677	4.571	30.472	67.677
3	0.902	6.011	73.688			
4	0.642	4.281	77.969			
5	0.530	3.536	81.505			
6	0.500	3.336	84.840			
7	0.406	2.709	87.550			
8	0.356	2.376	89.926			
9	0.321	2.143	92.069			
10	0.297	1.980	94.048			
11	0.252	1.678	95.726			
12	0.224	1.495	97.221			
13	0.164	1.092	98.313			
14	0.156	1.039	99.352			
15	0.097	0.648	100.000			

Extraction method: Principal component analysis.

Table 9. Rotated Component Matrix sorted by size for 15 technology items.

Items	Component	
	1	2
Te3	0.862	0.293
Te7	0.846	0.232
Te4	0.846	0.265
Te6	0.845	0.263
Te2	0.840	0.272
Te8	0.793	0.388
Te5	0.677	0.426
Te9	0.566	0.386
Te17	0.206	0.816
Te15	0.292	0.764
Te14	0.203	0.737
Te19	0.248	0.730
Te12	0.299	0.713
Te18	0.384	0.687
Te16	0.335	0.656

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

accommodate multiple users", respectively. This factor is is given the name *"Reports generator"* due to the fact that Pr11 has the highest loading factor (0.783).
2. Factor FPr2: This consists of Items Pr1 through Pr7, which are *"Project control"*, *"Project reporting system"*, *"Making business together"*, *"Reduce traveling time and cost"*, *"Reduce the number of working hours need to solve the task"*, *"Collaborative solutions"*, and *"Facilitates data collection in new product development project"*, respectively. Since Pr1 has the highest loading (0.804), this factor is given the name *"Tracking system"*.

In a similar manner, the names and contents of the two derived factors based on technology items are:

1. Factor FTe1: This consists of Items Te2 through Te9, which *are "Online meeting"*, *"Web conferencing"*, *"Seminar on the Web"*, *"Shared work spaces"*, *"Video conferencing"*, *"Audio conferencing"*, *"Online presentations"*, and *"Share documents"*, respectively. This factor is named *"Web solution"* since Te3 has the highest loading factor (0.862).
2. Factor FTe2: This consists of Items Te12 and Te14 to Te19, which are *"Access service from any computer (in Network)"*, *"Access shared files anytime, from any computer"*, *"Making business together"*, *"Web database"*, *"Provide instant collaboration"*, *"Software as a service"*, *"Virtual research centre for product development"*, and *"Can be integrated/compatible with the other tools and systems"*, respectively. Since Te17 has the highest loading (0.816), this factor is named *"Software as a service (SaaS)"*.

Analysis of Pearson's correlations indicates a number of positive relationships among the variables. Knowledge Workers is strongly correlated to Process and Technology, respectively (Table 10). The correlations vary by country, as illustrated in Tables 11 and 12. Fisher's Exact Test analysis support the fact that are insignificant differences ($p > 0.427$) between selected countries in terms of Knowledge Workers, Process and Technology in virtual teams.

The mean scores for frequency of use to exchange business information are illustrated in Table 11. Electronic mail is the most frequently used tool for all teams in Malaysia and Iran. Personal telephone call is the second most frequently used tool in both countries. Malaysian firms use more face-to-face interactions compared to Iranian firms. On the other hand, team-based communication technologies such as shared

Table 8. Descriptive statistics and correlations between variables (N=240).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	36.65	13.672		
2. Process	42.25	17.191	0.792*	
3. Technology	58.72	24.153	0.773*	0.853*

*Correlation is significant at the 0.01 level (2-tailed).

Table 9. Descriptive statistics and correlations between variables in Iran (N=136).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	36.14	14.251		
2. Process	42.66	17.165	0.791*	
3. Technology	60.77	24.429	0.838*	0.865*

*Correlation is significant at the 0.01 level (2-tailed).

Table 10. Descriptive statistics and correlations between variables in Malaysia (N=74).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	38.08	12.210		
2. Process	42.78	16.770	0.811*	
3. Technology	56.95	21.301	0.684*	0.795*

*Correlation is significant at the 0.01 level (2-tailed).

Table 11. Hypothesis testing results.

Hypotheses	Correlation/P value	Conclusion
H_1: Technology is positively correlated to Process in virtual teams.	0.853*	Supported
H_2: Technology is positively correlated to Knowledge Workers in virtual teams.	0.773*	Supported
H_3: Process and Knowledge Workers are positively correlated in virtual teams.	0.792*	Supported
H_4: There is an insignificant difference between the origins of virtual teams.	0.427**	Supported

*: $p < 0:01$, **: $p < 0:05$.

database, group telephone conference, electronic whiteboard and video conference are not often used. Although video conference is used less than once a month in Iranian firms, this tool is most often used by Malaysian firms. Video conferencing may prove effective in bringing remote members together if such tool is made available to the teams, and this may be a fruitful area for future research (Lurey and Raisinghani, 2001). Item Te6 addresses the need for video conferencing as a tool for virtual teams and a mean score of (N=218) 3.172 is attained, which indicates that this tool is essential for virtual team members. This finding agrees with the recommendation by Lurey and Raisinghani (2001).

The factors are summarized in Figure 3. This new model is based on Bal and Gundry (1999)'s model, whereby several modifications are derived from data analysis and survey findings. The model provides an overview of effective virtual teams for new product development in selected developing countries, namely, Malaysia and Iran.

Research limitations and directions for future research directions

The model developed for effective virtual teams is an

Table 12. Mean* scores for frequency of use for exchange business information tools in Iran and Malaysia.

Tools	Iranian teams (N=86)	Malaysian teams (N=31)
E-mail	4.62	4.97
Personal telephone call	4.54	4.63
Fax	4.02	4.00
Face-to-face interaction	3.65	4.23
Shared database/groupware	3.09	2.74
Meeting facilitation software	2.49	2.71
Web collaborative tool	2.42	2.65
Electronic newsletter	2.38	2.59
Voice mail	2.32	3.00
Electronic whiteboard	2.15	2.77
Group telephone conference	2.09	2.76
Video conference	1.85	2.43

*Frequency values- 1: never; 2: once a month; 3: once a week; 4: a few times a week; 5: daily.

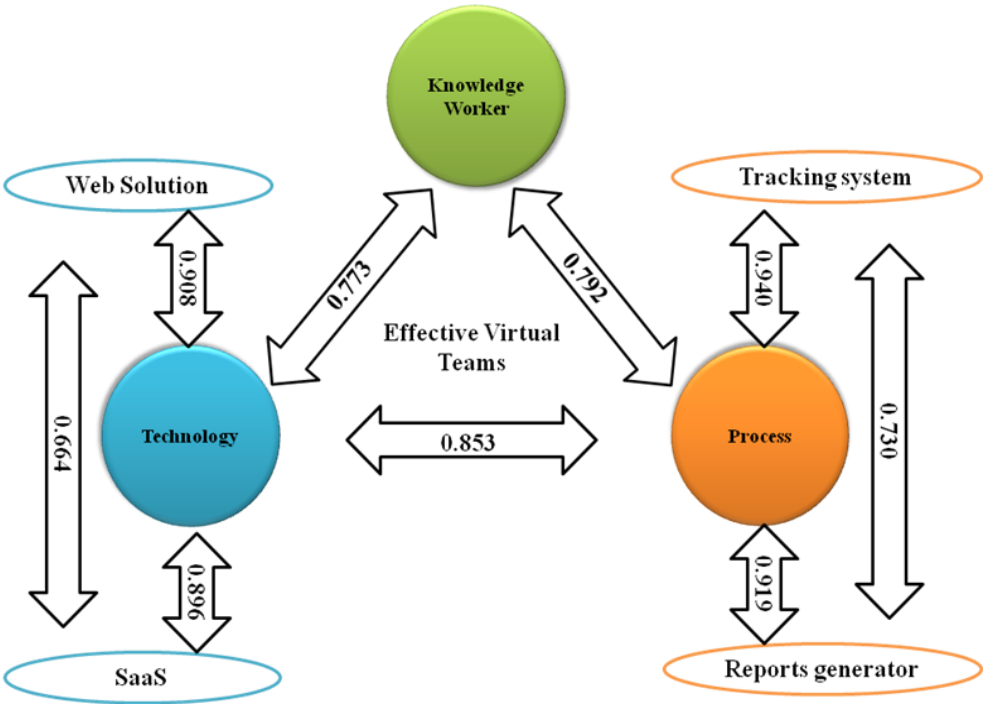

Figure 3. New model for effectiveness of virtual teams (Correlation is significant at the 0.01 level (2-tailed)).

initial attempt to identify the relationships between Knowledge Workers, Process and Technology factors, which are seen to be critical factors in the literature. The literature review is carried out based primarily on published refereed journal and conference papers, and thus, a number of important studies may have been excluded from this research. Therefore, it is possible that several factors which are excluded from the framework could be important for evaluation of virtual teams. The study is limited by the sample size and population. Future research is required to examine the model and verify it by a larger sample of virtual teams from different sectors since this study is constrained to the manufacturing sector. With a larger sample, it is possible to compare the

results between countries more precisely. Twelve crucial factors have been identified in this research to move forward from conventional teamwork to successful virtual teamwork in new product development.

Conclusions

This paper is comprises of a literature review and field survey to identify the key factors which should be considered to create effective virtual teams. The findings provide a useful insight into how virtual team efficacy is formed and what its consequences are in the context of virtual teams. The results of the study indicate that Technology and Process are tightly correlated and need to be considered early in virtual teams. It is found that the role of Knowledge Workers in virtual teams is significant, which agrees well with the findings of Bal and Teo (2001b) and Ale Ebrahim et al. (2009d). The survey results reveal that all eight items in the Knowledge Workers factor remained while the remaining items are reduced into two main factors. Future research is needed to investigate the individual effects of Knowledge Workers, Technology and Process on virtual team effectiveness. *"Software as a service"*, *"Web solution"*, *"Report Generator"* and *"Tracking system in effective virtual teams"* should be taken into account in future research. E-mail is the most frequently used tool for all teams in Malaysia and Iran and therefore, managers of virtual teams should provide enhanced infrastructures for effective communications between team members.

Future research is essential to develop a comprehensive study which combines survey and case studies in companies of different sizes (e.g. multinational companies, and small and medium enterprises) and various types of activities (for example, research and development and new product development). Such a study is crucial to further develop the model and verify such a model using a larger sample of virtual teams from different sectors. With a larger sample, it is possible to compare the results between countries more precisely.

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IEMS Vol. 10, No. 2, pp. 109-114, June 2011.

The Effectiveness of Virtual R&D Teams in SMEs: Experiences of Malaysian SMEs

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Received, January 12, 2011; Revised, April 12, 2011; Accepted, April 19, 2011

Abstract. The number of small and medium enterprises (SMEs), especially those involved with research and development (R&D) programs and employed virtual teams to create the greatest competitive advantage from limited labor are increasing. Global and localized virtual R&D teams are believed to have high potential for the growth of SMEs. Due to the fast-growing complexity of new products coupled with new emerging opportunities of virtual teams, a collaborative approach is believed to be the future trend. This research explores the effectiveness of virtuality in SMEs' virtual R&D teams. Online questionnaires were emailed to Malaysian manufacturing SMEs and 74 usable questionnaires were received, representing a 20.8 percent return rate. In order to avoid biases which may result from pre-suggested answers, a series of open-ended questions were retrieved from the experts. This study was focused on analyzing an open-ended question, whereby four main themes were extracted from the experts' recommendations regarding the effectiveness of virtual teams for the growth and performance of SMEs. The findings of this study would be useful to product design managers of SMEs in order to realize the key advantages and significance of virtual R&D teams during the new product development (NPD) process. This is turn, leads to increased effectiveness in new product development's procedure.

Keywords: Virtual Teams, New Product Development, Survey Finding, Small and Medium Enterprises.

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) are major contributors for industrial economies (Eikebrokk and Olsen, 2007). The significance of SMEs in economic growth has rendered SMEs a central element in much recent policymaking (Hoffman *et al*., 1998). SMEs appear to be appropriate units as network nodes due to their lean structures, adaptability to market evolution, active involvement of versatile human resources, ability to establish subcontracting relations and good technological level of their products (Mezgar *et al*., 2000). SMEs possess advantages with regards to flexibility, reaction time and innovation capacity, and therefore SMEs play a major role in the new economy (Raymond and Croteau, 2006). Gassmann and Keupp (2007) found that managers of SMEs should invest less in tangible assets and more in areas which would directly enhance their future competitive advantage such as R&D, which would generate knowledge, as well as in their employees' creativity to stimulate incremental innovations in existing technologies. A crucial trend for enabling the creation and transfer of new

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knowledge in and to SMEs is by the development of virtual collaborative environments and networks to increase their innovation abilities as a single unit and capabilities of the network as a whole (Flores, 2006). Virtuality has been presented as a solution for SMEs aiming to increase their competitiveness (Pihkala *et al*., 1999). Virtual teams reduce time-to-market for new products (May and Carter, 2001). Lead time or time-to-market has been generally accepted as one of the vital keys for success in manufacturing companies (Sorli *et al*., 2006).

Ale Ebrahim *et al*. (2009a, 2010) derived the strengths and weaknesses of virtual teams in SMEs in their recent comprehensive reviews. The effectiveness of virtual teams in Malaysian manufacturing SMEs has not been reported, and therefore, the main objective of this study is to present the primary benefits of virtual teams for the growth of SMEs. The scope of this study is limited to the experiences of Malaysian manufacturing SMEs' expertise, which involve virtual teams. In this paper, the effectiveness is related to the performance and collaboration within virtual teams in order to reduce costs and time of R&D projects. This paper presents a portion of the results obtained from an empirical research carried out during the past two years within manufacturing SMEs in Malaysia. In moving towards virtual R&D teaming, an understanding of existing practices is important. In this paper, a review of recent literature pertaining to virtual R&D teams is presented, whereby the primary definition of virtual R&D teams and its relationship with SMEs are introduced. Following this, the research methodology and data analyses are detailed, and the directions for future research are presented in the final section of this paper.

2. VIRTUAL R&D TEAMS AND SMEs

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams, which interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and their works are coordinated mainly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel *et al*., 2005). Among the different definitions of virtual teams, the following concept is one of the most widely accepted definitions (Ale Ebrahim *et al*., 2009c): "Virtual teams are small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks" (Ale Ebrahim *et al*., 2009b). Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities. The members of a virtual R&D team utilize different degrees of communication technology to complete the research without space, time and organizational boundaries.

SMEs are not scaled-down versions of large companies as they possess different characteristics which distinguish them from large corporations. SMEs vary across different countries and cultures, and they are independent, multi-tasked and cash-limited as well as based on personal relationships and informality. Additionally, SMEs are managed actively by the owners, highly personalized, largely localized within their areas of operation and are largely dependent on internal sources for financial growth (Perrini *et al*., 2007). In order to survive in the global economy, SMEs have to improve their products and processes by exploiting their intellectual capital in a dynamic network of knowledge-intensive relations inside and outside their borders (Corso *et al*., 2003). Therefore, if small firms intend to create a step change in their technological and innovation base, they may have to rethink their approach to cooperation (Hanna and Walsh, 2002). SMEs need to cooperate with external partners to compensate for other competencies and resources. This is especially the case for R&D, in which SMEs face specific problems compared with large firms (Pullen *et al*., 2008). Levy *et al*. (2003) stated that SMEs are knowledge creators; however, they are poor in knowledge retention. They need to be proactive in knowledge sharing arrangements to recognize that knowledge has value, and the value added is derived from knowledge exchange (Egbu *et al*., 2005). Virtual R&D teams can provide such knowledge sharing. There is a general movement towards virtual R&D teams, as virtual R&D teams facilitate the spreading of risks and sharing or costs among a network of companies (Gassmann and Von Zedtwitz, 1999, Kratzer *et al*., 2005). Hence, virtual teams are important mechanisms for organizations such as SMEs seeking to leverage scarce resources across geographic and other boundaries (Munkvold and Zigurs, 2007).

3. METHODOLOGY

The data for this research was gathered from desk study and survey. Web-based questionnaires were designed and delivered to Malaysian manufacturing SMEs, which included close-ended and open-ended questions. This study clustered one open-ended question. Clustering involves searching the data for related categories with similar meaning. This analysis is known as Thematic Analysis since the main purpose during the start of the analysis is to look for themes. When a set of themes is formed, more advanced analyses can be employed to look for clusters and patterns among them (Abdul Rashid, 2009). In this analysis, any sentences which provide significant meaning were extracted and organized into different categories.

4. DATA COLLECTION AND ANALYSES

The research was targeted at manufacturing SMEs within Malaysia, which employed virtual teams in their organizations. Online questionnaires were sent to relevant SMEs in order to obtain the viewpoints from experts involved with virtual teams in SMEs. Denscombe (2006) encouraged social researchers to use web-based questionnaires with confidence, and therefore online questionnaires were distributed to SMEs in Malaysia via email. The participants were directed to a website, and the surveys were completed online.

The questionnaires consisted of three sections, as follows:

a) Demographic information: The results obtained from this section enable the selection of suitable enterprises which complied with the definition of SMEs.

b) Current status of virtual teams: The first question in this section clarified the utilization of virtual teams in the enterprises. Respondents who selected "No" in answer to the question indicate that the organizations did not possess experience with virtual teams, and were directed to Section C in the questionnaires. The final open-ended question which concerns the effectiveness of virtual teams on the organization's growth and performance, were analyzed in this research.

c) Requirements for establishing virtual teams: The results of this section was not included in this research.

The surveys were tested preliminarily among 12 experts, followed by improvements, modifications and distribution. Finally, questionnaires consisting of open and close-ended questions were distributed to 356 Malaysian manufacturing SMEs. The major target groups with regards to the size of the organization and industrial field were Managing Directors, R&D Managers, New Product Development Managers, Project and Design Managers as well as appropriate personnel who were involved significantly with R&D issues in the organizations. A total of 74 usable questionnaires were received, which represented a 20.8 percent return rate. The response rate was deemed satisfactory since accessing high-rank personnel was difficult. Table 1. It was found that a total of 42 SMEs fulfilled the criteria of this research and therefore the remaining respondents were dropped from the analysis. Descriptive statistics were used to analyze the responses. Table 2 shows the frequency of using virtual teams among the sampled Malaysian SMEs. The results showed that 33.3% SMEs employed virtual teams. This indicates that applications of virtual teams in manufacturing SMEs are still in its infancy.

Table 1. Summary of online survey data collection.

Number of emails sent to Malaysian Firms	2068
Total Responses (Click the online web page)	356
Total Responses/Received questionnaire (%)	17.2
Total Completed	74
Total Completed/Received questionnaire (%)	20.8

It is known that open-ended questions provide fewer prompts and impose the fewest limits. It is for these reasons open-ended questions evoke the most authentic possible responses from respondents (Bobrow, 1997). Open-ended questions are good for prompting a respondent's attitude or feelings, likes and dislikes, memory recalls, opinions, or to request for additional comments. However, open-ended questions are time-consuming and particularly difficult to answer. After considering all advantages and disadvantages, only a few open-ended questions were used in the online questionnaires. In this research, only one open-ended question was considered, which was: *Please explain the total effectiveness of virtual team system/tool on the company's growth and performance, before and after implementation?*

Table 2. Cross-tabulation between country and virtual teams.

	Using Virtual Team		Total
	Yes	NO	
Count	14	28	42
%	33.3%	66.7%	100.0%

5. RESPONDENTS' COMMENTS

It was found that a great majority of the respondents answered the open-ended questions. Summarizing the results of open-ended questions was not simple due to the different levels of management and individuals, subjective wording and phrasing of the responses. However, several good comments were selected, and are shown as quotes in Table 3. The comments represent the actual experiences of the respondents, which are in accordance with (Ebrahim *et al*., 2010, May and Carter, 2001, Bouchard and Cassivi, 2004). The virtual teams' managers were a good source to confirm the benefits of virtuality due to their experiences. Since open-ended questions provide a rather qualitative information, simple thematic analysis was particular suitable to extract information from such questions. In this research, simple thematic analysis was performed by conducting two levels of clustering analysis. Thematic analysis is commonly used by qualitative researchers and is usually recognized as a tool rather than a method (Abdul Rashid, 2009). In this analysis, the data were clustered into two levels, whereby lower level is Level 2, and higher level is Level 1. Level 1 was then identified as theme. Table 4 shows the clusters and theme generated from the simple thematic analysis. From this analysis, it was found that

Table 3. Comments on the effectiveness of virtual teams for the company's growth and performance (Compare before and after implementation).

Case No.	Respondents' comments
1	Cost saving, time saving, and great convenience. These will enhance the flow of the projects of a company and speed up the progress of our work.
2	Reduce time consumption
3	Time and cost are saved.
4	Since we have different manufacturing location around the world, our marketing department is located away from R&D, the virtual tools are the one that brings us closer and helps in decision making, faster product release and meeting customer satisfaction.
5	Virtual team system/tool is merely ASSISTANCE to the current workload.
6	Save time, money and energy
7	In my opinion, virtual team can make a good connection between the entire assets of organization.
8	With start virtual team system we improved in my performance
9	The virtual team system/tool is effective and can be helpful
10	In both it is seriously important.
11	1) The company could growth faster, due to overcoming to distance and time by using virtual system 2) If system will be managed in an effective manner, the performance is increased due to power of the tools
12	We did some activities in our company to reduce costs as follows : 1-We arranged virtual network suppliers 2-They arranged R&D teams for our orders 3-our R&D department manage overall activities then we can reduced employees from 50 to less than 20
13	1) Capable for attracting experts and knowledge workers 2) declining ineffectual face to face meetings-improving work environment-Reducing time of trips
14	After correct implementation and good training of users, the growth of company is about 6 from 10 (10 is excellent and 0 is bad)
15	In my opinion it is impossible to work without such systems in the extremely mobile world we face these days.
16	Reduce unnecessary time waste and expedite product outcome
17	We demonstrate a positive annual trend in all factors important to us.
18	There is some effect but might be more effective while internal works are considered. In the case of international cooperation it depends strongly on consortiums formed for project executions

there are four main benefits of virtual team/tool on the growth and performance of enterprises. These benefits are: reduced R&D costs and time, more effective R&D, better output and increased coordination.

6. CONCLUSIONS

Despite the enormous benefits of employing virtual R&D teams in manufacturing SMEs, the application of virtual teams by most enterprises is still in its infancy. The study showed that one-third of Malaysian manufacturing SMEs have employed virtual R&D teams. Competitive advantage is now becoming available to SMEs through geographically open boundaries created by virtual teams. Existing practices within Malaysian manufacturing SMEs experts, who were involved with virtual teams, proved four-fold benefiting from the cross-functional virtual R&D teams, namely: 1-Reduced R&D cost and time, 2-More effective R&D, 3-Better output, 4-Increased coordination. Virtual R&D teams give better team outputs, reduce time-to-market, reduce travel costs and demonstrate the ability to tap selectively into centers of excellence. Additionally, virtual R&D teams enable the use of the best talents regardless of location, giving a greater degree of freedom to individuals, shorter development times, and quicker response to changing business environments as well as higher team effectiveness and coordination. Therefore, the decision for setting up virtual R&D teams in SMEs is not a choice, but a necessity.

This paper is probably the first to present an empirical research on virtual R&D teams, which is limited to Malaysian manufacturing SMEs. Future research is needed to investigate the four-fold benefits of virtual R&D teams by a larger sample from different

sectors. Although several studies have been carried out on the use of virtual R&D teams in large companies, applications within SMEs remain undocumented. Hence, future research should be focused on this gap and to search for a virtual collaborative system for SMEs which are dispersed geographically. Such a collaborative system should virtually link SMEs to enable the engaging members to focus on their specialized tasks as well as share their knowledge and experience (information resources). This will create agile manufacturing environments and enterprises.

Table 4. Clustered theme and cluster extracted from Table 3 (virtual team effectiveness).

No.	Cluster Level 1 /Theme	Cluster Level 2
1	Reduced R&D cost and time	Cost saving, Time saving Reduce time consumption Faster product release Reduced employees Reducing time of trips Reduce unnecessary time wastage
2	More effective R&D	Speeds up work progress Great convenience Facilitates decision-making Assists the current workload Improved performance Virtual team system/tool is effective Capable of attracting experts and knowledge workers
3	Better output	Enhances the flow of projects of a company Meets customer satisfaction Increases performance Improves work environment Expedites product outcome Demonstrates a positive annual trend
4	Increased coordination	Brings us closer Good connection between the entire assets of organization

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