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Virtual R&D Teams: A Sustainable Infrastructure for Promoting SMEs

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Abstract—Small and medium sized enterprises (SMEs) are a major part of the industrial economies. Their survival and growth has therefore been a prominent issue. Research and development (R&D) enables firms to create new technologies and/or to build on existing technologies obtained through technology transfer. Nowadays unpredictable environment suggests that many firms seek new ways of conducting their business through some kind of R&D activities to make a profit and stay ahead of the competition. 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. SMEs need to focus on core competences for efficiency matters; they need to cooperate with external partners to compensate for other competences and resources. Responding to the increasing de-centralization and globalization of work processes, many SMEs have responded to their dynamic environments by introducing virtual teams. Virtual teams are growing in popularity. By a comprehensive literature review this article following define a virtual teams, SMEs and its characteristics, addressing a sustainable infrastructure for promoting SMEs. Finally conclude that managers of SMEs should invest less in tangible assets, but more in the areas of expanding virtual R&D activities which will directly generate their future competitive advantage. Future research need to elaborate the effect of virtual R&D team working on the performance of SMEs.

Keywords: Virtual Team, Small and medium sized enterprises (SMEs), R&D, Literature Review

I. INTRODUCTION

Small and Medium Enterprises (SMEs) play an important role to promote economic development. The internationalization of R&D network is recent phenomenon [1]. 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 [2]. 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 [3]. Internet will become in the future an important source of competitive advantage [4]. 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. The employed Web Services technology, although very popular nowadays but it is still not mature enough, so dealing with it can bring new findings [5]. Considering that R&D teams need to access and retrieve information from as many sources as possible [1], virtual teams are important mechanisms for organizations seeking to leverage scarce resources across geographic and other boundaries [6].

Faced with the challenges of increased globalization of markets and of technological change, SMEs need reinforced support through transnational research cooperation to enhance their innovation and research investment. SMEs' survival depended on their capability to improve their performance and produce goods that could meet international standards [7]. In other words, a certain level of competitiveness may be a prerequisite for an SME's survival when dealing with dynamic conditions in the business environment. To compete with global competition and, overcome rapid technology change and product variety proliferation in the new manufacturing environment, SMEs must be able to sustain product innovation [8]. Internationalization holds much potential for the growth of SMEs [9]. 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 but also the capabilities of the network as a whole through collective learning [10].

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In this paper first based on earlier work define virtual teams, SMEs and its characteristics, addressing a sustainable infrastructure for promoting SMEs. Finally highlight that managers of SMEs should invest less in tangible assets, but more in the areas of expanding virtual R&D activities which will directly generate their future competitive advantage. This paper would help researchers, managers and policy makers to better foster virtual R&D teams in SMEs. Camarinha-Matos and Afsarmanesh [11] 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.

II. DEFINITION OF VIRTUAL TEAM

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 [12]. Gassmann and Von Zedtwitz [13] 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.) [3], different authors have identified diverse. From the perspective of [14] 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 [15] 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: [16], “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 [17].

III. VIRTUAL TEAMS CHARACTERISTICS

Virtual R&D teams which members do not work at the same time or place [18] often face tight schedules and a need to start quickly and perform instantly [6]. Virtual team may allow people to collaborate more productivity at a distance, but the trip 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 [19]. Virtual teams reduce time-to-market [20]. Lead Time or Time to market has been generally admitted to be one of the most important keys for success in manufacturing companies [21]. 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	Reference
Reduce relocation time and costs, reduced travel costs	[2, 22-26]
Virtual teams reduce 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 [27]]	[20, 21, 26, 28-32]
Ability to tap selectively into center of excellence, using the best talent regardless of location	[2, 25, 33, 34]
Greater productivity, shorter development times	[22, 32]
Producing better outcomes and attract better employees	[23, 35]
Provide organizations with unprecedented level of flexibility and responsiveness	[16, 28, 36]
Respond quickly to changing business environments	[24, 32]
Sharing knowledge, experiences	[37, 38]
Enable organizations to respond faster to increased competition	[36, 39]
Better team outcomes (quality, productivity, and satisfaction)	[40, 41]
Higher team effectiveness and efficiency	[20, 42]

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

Disadvantages	references
lack of physical interaction	[23] [2, 26, 43]
Decrease monitoring and control of activities	[44]
Challenges of determining the appropriate task technology fit	[45, 46]
Challenges of managing conflict	[46, 47]
Cultural and functional diversity in virtual teams lead to differences in the members’ thought processes. Develop trust among the members are challenging	[26, 48, 49]

IV. R&D AND DISTRIBUTED TEAM

Research and development are subject to different location drivers[50]. Many firms started to acquire their knowledge from external sources [51]. R&D units in foreign countries have gained more responsibilities and competencies besides the still-existing traditional mode of adapting products developed in the home country and technical support for production abroad [52]. Trends over the last decade have seen China and India emerge as attractive R&D destinations for U.S. [53]. In a recent study, Li and Yue [54] building on von Zedtwitz and Gassmann's [50] seminal work, suggested that international research and development processes have two key dimensions: functional focus (either research oriented or development oriented) of R&D activities and geographic dispersion or concentration of R&D sites. These two dimensions lead to four categories of R&D configuration in a host country[54].:

1. Concentrated research and development;
2. Dispersed research and concentrated development;
3. Concentrated research and dispersed development;
4. Dispersed research and development.

Changes in telecommunications and data processing capabilities make it possible to coordinate research, marketing and production operation around the world [55]. Technological change is a highly dynamic process that may quickly relocate to take advantage of optimum conditions for growth [53]. For most R&D teams, being virtual are a matter of degree [14]

V. SMALL AND MEDIUM ENTERPRISES (SME)

Small and medium sized enterprises (SMEs) are a major part of the industrial economies [56, 57]. Their survival and growth has therefore been a prominent issue. Beck et al.[58] explores 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 that 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 [30].

Small and Medium Enterprises (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 [59]. More importantly SMEs play an important role in foreign direct investment (FDI) [60]. Many economists believe that the wealth of nations and the growth of their economies strongly depend upon their SMEs' performance [61]. In many developed and developing countries, small and medium-sized enterprises (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 [62]. 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 [63].

VI. VIRTUAL R&D TEAMS AND SMES

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 [64]. 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 [65]. The traditional independence of small firms is being replaced by a network environment [66]. Generally speaking three types of technologies are picked up by SMEs: small scale technologies, labor intensive technologies, and specialized high technology know-how [55] creating networks in the cycle of the management of these technologies is of a high importance.

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[67]. Hanna and Walsh [66] found that if small firms want to make a step change in their technological and innovation base they may have to rethink their approach to cooperation. SMEs need to focus on core competences for efficiency matters; they need to cooperate with external partners to compensate for other competences and resources. [68]. 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 [69]. 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 [70]. Especially in the emerging and dynamic markets the shared knowledge creation and innovation may speed up market development [71]. Gassmann and Keupp [72]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).

VII. CHARACTERISTICS OF SMES

In order to have a better understanding of SMEs behavior, a brief knowledge of the characteristics of SMEs is a must therefore the major characteristics of SMEs are listed in the Table 3 and Table 4 .SME has different characteristics that

distinguish them from large corporations and that can of course change across different countries and cultures; they are generally independent, multi-tasking, cash-limited and based on personal relationships and informality, as well as actively managed by the owners, highly personalized, largely local in their area of operation and largely dependent on internal sources to finance growth [73].

Table 3: some of the major advantages of SMEs

Advantages	Reference
Generally dominated by the entrepreneur (owner-manager)	[74-76]
Ability to respond quickly to customer requests and market changes	[74, 75, 77-80]
Being flexible and responding rapidly to change, dynamic behavior	[59, 64, 75, 77, 81-83].
Driven by client demands, Quick decision	[59, 75, 84, 85]
Un bureaucratic, processes and flat and flexible structures	[59, 75, 77, 85-88]
SMEs in most cases operate in a dense network of inter-firm relationships and consequently manage a great amount of information	[89, 90]
Are good at multi-tasking due to SME's entrepreneurs are generally "all-rounders" with basic knowledge in many areas	[75, 88]
Focus more on medium-term survival than long-term profits	
Creating new jobs and reducing unemployment	[85, 91, 92]
SMEs are knowledge creators	[76, 93]
Have significant intangible assets	[94]

Table 4: some of the major disadvantages of SMEs

Disadvantages	Reference
Scarce resources and manpower	[9, 66, 68, 82, 88, 94, 95]
limited degree of information technology (IT) implementation	[57, 67, 76, 87, 95, 96]
Difficulty in finding the financial support for technical work, human resource, plant and equipment, marketing	[8, 59]
Difficulty converting research and development into effective innovation, that is to say, innovation that leads to positive return/high growth	[97, 98]
Lack some of the essential resources for innovation, Severe resource limitations in R&D	[87, 99-101]
May not have formal R&D activities	[102]
SMEs formulate strategies on the basis of what is available to them	[7]
Rely on outdated technology, labor intensive and traditional management practices	[58, 59]
Lagging in the exporting	[103]

VIII. CONCLUSION AND DIRECTIONS FOR FUTURE RESEARCH

One of the main producers of wealth and prosperity of industrialized countries is the existence of sustainable systems, capable of converting technological innovation assets into substantial levels of industrial productivity, wealth and global competitiveness [104]. A global market requires a short product development cycle; hence SMEs are also forced into altering from sequential to concurrent product development. SMEs are the key players in the innovation system and the economy of a country, despite their size limits they bring about a lot of creativity into the products and services they offer through research and development. Virtual teams are dramatically influencing organizations and doing virtual R&D for 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 [72], 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. Simple transmission of information between new product teams' members is not adequate; the virtual R&D team should also constructively interact in effective communication. Therefore as the first step managers of SMEs should move towards the concept that virtual teams are vital factors in modern organizations and as the next step an action plan for bringing the concept to practice shall be devised and executed.

As another important point the evidence shows management of virtual R&D team in SMEs is largely in its infancy. While most of the research activities relevant to SMEs do not encourage and support international research cooperation and technology transfer, such networking will be potentially advantageous. Such potential advantages have been listed in Table 3. Hence it is vital to bridge this gap and unlock growth opportunities for SMEs through research, and help them carry out or outsource research in order to develop new technology based products, processes and services, exploit research results, acquire technological know-how and train their employees to incorporate new development processes.

The extensive review shows that while a considerable number of studies and research efforts have been conducted and concentrated on SMEs 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 SMEs 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 processes, operating innovatively, effectively and efficiently is of a high importance, but the

issue has poorly been addressed simultaneously in the previous studies, specially from the perspectives of SME collaboration. In many cases the knowledge required in the development of new products, services or processes does not fully reside inside the organizational boundaries. Consequently in high-risk areas, R&D collaboration can be used as an optional strategy for risk sharing and mitigation, among SMEs which are suffering from lack of resources.

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