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Review

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

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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

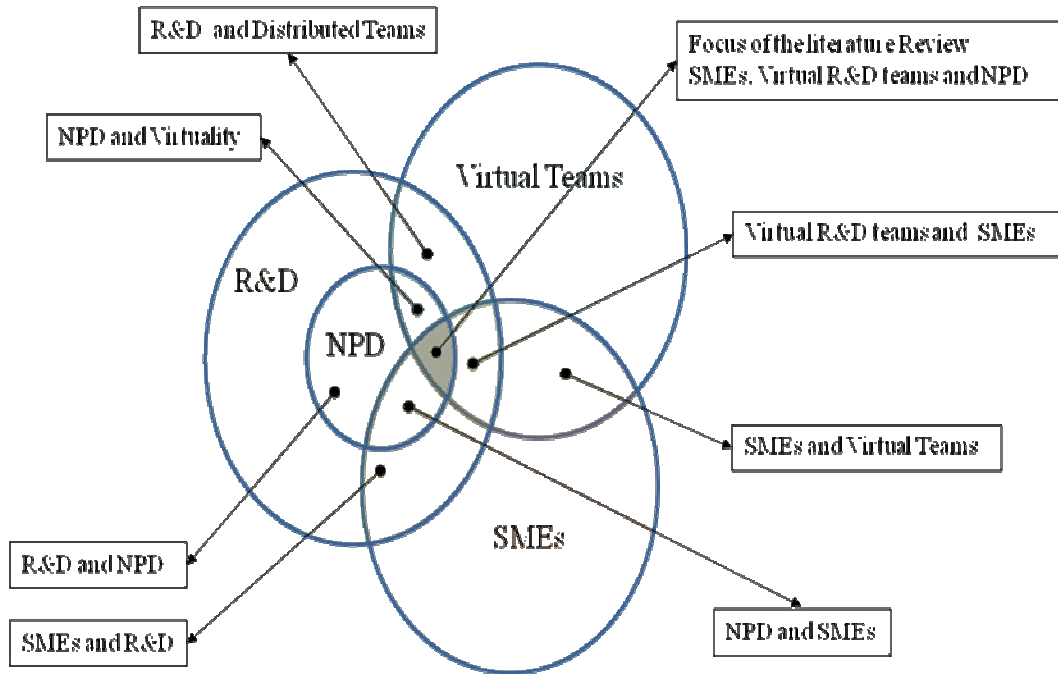


Figure 1. Literature fields included in the review: A general model.

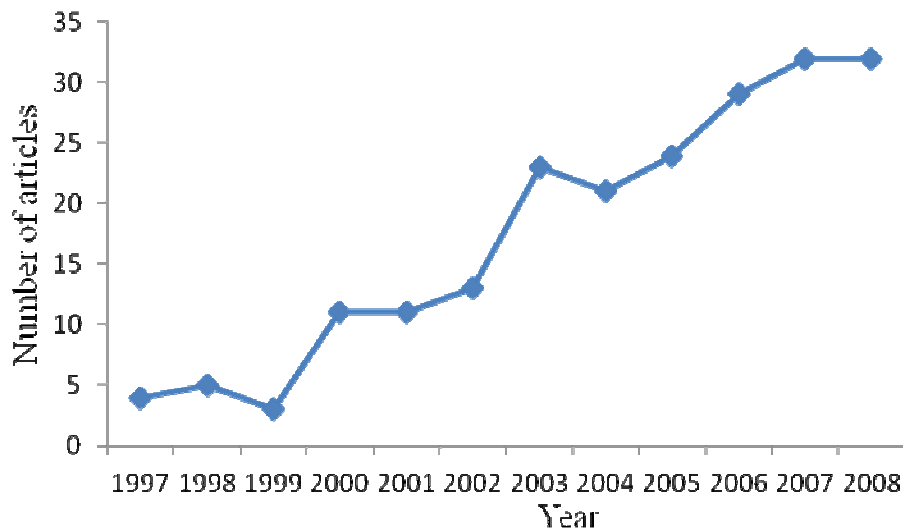


Figure 2. Publication trend.

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 employees 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 (Richtner 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 Fernández, 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 Fernandez, 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 et 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 Fernandez, 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 Zigungs, 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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