

Managing Virtual Product Development team: A Review

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Abstract

Although there are many potential benefits associated with the use of virtual product development teams, exploiting these benefits requires an appropriate management. Managing virtual product development team is a critical issue as many of these teams fail to accomplish their goals. Review of previous literature shows that body of knowledge in managing virtual product development teams is fragmented and inconsistent. The main objective of this paper is to categorize the previous research on the subject of virtual product development team management in order to integrate the research into a thematic model and to enable recommendations for future research. So, this study reviews and summarizes empirical research in the field, also conceptual and qualitative papers, experiences, reports and explorative case studies. Results show that there are three fields of research in this area, including: Virtual production and Virtual team in Product Development, Managing virtual team in R&D¹ and product development, Managing global virtual product development teams. In order to organize previous studies in this area, a thematic map is proposed which shows the structure and sequence of research. Finally, a comprehensive discussion on the future directions in this field is proposed.

Keywords: Virtual teams; Product Development; Virtual Production; Global Managing.

1. Introduction

Today, the meaning of team working in the business context has changed a lot. We used to call a group of people working together in the same location to achieve a common goal a “team”. In recent years, we have seen a decentralization of teams in local markets (Hertel et al., 2005). The rapid growth of new communication and information technologies has enabled teams to be formed virtually. Virtual teams can be found in various fields like programming, project management (Gassmann & Zedtwitz, 2003), research and development, new product design, problem solving or customer services. They also can be used in non-economic areas such as science (Finholt, 2002). This is why virtual teams are becoming prevalent.

Supported by modern information and communication technologies, virtual project teams and virtual product development teams were formed to facilitate transnational innovation

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processes (Curseu et al., 2007) and deliver valuable products to the market and consumers (Ale Ebrahim et al., 2009b). Virtual team's boundary can expand and shrink flexibly in changing environment to match with the project necessities. These characteristics cause virtual product development teams to be an important element of future organizations (Furst et al., 2004). Due to increasing decentralization and globalization of work processes, many producer and R&D organizations have responded to their dynamic environments by introducing virtual product development teams, in which members are geographically dispersed and coordinate their works with the aid of information and communication technologies (Skageby, 2011).

In the dynamic rapid changing, 21st century organizations are constantly involved with adapting to the environment and market demands. In such situation, virtual product development teams can offer high-quality, low-cost, rapid solutions to complex organizational problems (Gassmann et al., 2009), and enable organizations enlisting the talents and expertise of employees and non-employees by eliminating space and time barriers (Curseu et al., 2007). However, applying virtual teams is not always satisfactory. There is some growing evidence that virtual product development teams fail more often than they succeed (Furst et al., 2004). It is important how to take benefits of these teams. This guides us to the notion of team management.

There are different views of virtual product development teams in the literature. Despite the growing prevalence of virtual product development teams in organizations, our knowledge about efficient management of these teams is still undeveloped (Axtell, Fleck, & Turner, 2004; Kirkman, Rosen, Tesluk, & Gibson, 2004). According to the literature review by Hertel et al. (2005), body of knowledge in managing virtual product development teams is fragmented and findings are inconsistent. They insist that the role of these teams as a critical technological force has been underestimated in previous research. The present study reviews the previous literature in the field of virtual product development teams to examine its fragmentation and presents an integrative framework to direct the future research in this field. The main objective of this review is to categorize the previous research on the management of virtual product development teams and integrate the current body of knowledge into a thematic model that enables recommendations for future research.

In the second section of this paper, theoretical background, nature and definition of virtual team and virtual product development team management are provided. The third section deals with the research method. Available empirical and conceptual papers and explorative case studies related to the management of virtual product development teams are summarized as results. Then results are categorized in three fields of research and a thematic model is proposed, which directs the future research in this field.

2. Theoretical Background

What do we mean by 'virtual team'? Since there are many forms of virtual teams with different functions and affiliations (Zigurs, 2003), proposing a unique and agreed upon definition of these teams is difficult. The term 'virtual' was first used with 'international project management' in management literature conveying a flexible and modern solution for project management. Since then, it has been used differently in management literature with other concepts (Gassmann & Zedtwitz, 2003). Goldman et al. (1995), define 'virtual team' as "an opportunistic alliance of core competencies distributed among a number of distinct operating entities within a single large company or group of companies". This definition stresses on three aspects: 1- alliance of some entities 2- which are distributed and are not centralized 3- alliance or sharing of competencies. These three aspects could happen where a common interest or goal is conceivable, whether inside an organization, between

organizations or between individuals or other social entities. Some of the researchers insist on electronic media for communication between team members (Hertel et al., 2005). Other researchers have explicated some of the virtual teams' characteristics like temporal nature and existence for a limited time and a certain purpose, no hierarchical structure and no central coordination (Chiesa and Manzini, 1997). Other conceptualization of virtual team exists in the literature, for example "a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across space, time, and organizational boundaries with links strengthened by information, communication and transport technologies"(Gassmann & Zedtwitz, 2003). Along with Ale Ebrahim et al. (2009a) 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.

In sum, based on Goldman et al., (1995) we define virtual teams as the alliance of two or more dispersed entities for the realization of a common purpose through exchange of information, knowledge idea and other resources, basically communicating with the aid of IT.

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., 2004, 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)

Today, the nature of organizational team has changed significantly due to changes in industries and organizations and also changes in the nature of the works they do (Boutellier et al., 1998, Ale Ebrahim et al., 2009b). Organizations search for new strategies that are totally different from what was in the classic Management Science. This is reinforced by the increasing globalization of research, technologies and innovation, by new information technologies and by new organizational forms and business models' potential (Gassmann & Enkel, 2004). Businesses have become more distributed across geography and industries (Hertel et al., 2005). In many cases different stages of production take place in different locations. Offshoring has become a common strategy chosen by many businesses.

Organizations constantly seek to reduce their cost and create more value to their customers. They have to innovate to survive in the competitive environment. They search for fast ways of creating new ideas and commercialization of them and try to reduce cost and distribute the risk associated with the innovation. That is why most of the firms take open innovation approach. Firms need to open up their organizational boundaries to let information and knowledge flow in from the outside for conducting co-operative innovation processes with customers, suppliers and other conceivable partners (Gassmann & Enkel, 2004). Relationships between people inside the organization and those previously considered outside are becoming more important. Organizations have discovered the value of collaborative work (Bell & Kozlowski, 2002). All these changes in organizations and their strategies have changed the nature of organizational teams, how they are formed and how they interact (Leenders et al., 2003). New virtual teams have been popular and used in many organizations. Team members include people from outside of the organization and most of the people are members of multiple teams. Some other characteristics of virtual teams are: distributed team members across organizations and geography, continuous team formation and reformation and multiple reporting relationships with different parts of the organization at different times (Bosch-Sijtsema&Rispens, 2003).

One of the most important issues in a team is to direct individual efforts to the common goal. Team members have different wants and interests. Furthermore, each team member has its own conceptualization of the reality and understanding of the problem and works to be done. So, conflicts arise. It is necessary to control individual interests because they would outweigh the common goal of the team. Also, it is necessary to monitor each member's activity to make sure the problem is well understood and efforts are along with other members' endeavors. Therefore, team management is a critical task. There would be no benefits derived from team working without a suitable management. Managing a virtual product development team is not similar to a face-to-face team management (Maznevski and Chudoba, 2000) and is more difficult. According to Kimball (1997), virtual product development team management can be frustrating and also disappointing when interaction with others in the group results in information overload, topic drift, or conversations that are not valuable.

Managing virtual product development team has become a critical issue from the time that the use of virtual teams, especially in product development projects, became widespread (Curseu et al., 2007). Furst et al., (2004) suggest that managing a virtual product development team requires new methods of supervision. According to Lee-Kelley and Sankey (2008), Thomas and Bostrom (2005), managing virtual product development team requires competency, willingness for self-management, appropriate application of technology and networking ability, and cultural and interpersonal awareness. When these characteristics are provided, the virtual team's manager can help in minimizing conflicts that can occur over role assignments (Blackburn et al., 2003).

In recent years, virtual teams have gained the attention of researchers in several fields such as innovation and product development. A number of precious literature reviews have been done on virtual teams. Powell et al., (2004) conducted a literature review on virtual teams in general. Based on Saunders' model of lifecycle (2000), they categorized previous research on the basis of variables which were the focus of research. Four categories were proposed: 1- input: which contains research focused on design and relation structure of virtual team 2- output: those research focused on performance and output of the team 3- socio-emotional: papers focused on factors affecting team effectiveness, such as trust and cohesion processes 4- task processes: articles focused on processes of working together in a team such as

communication and coordination. They also categorized research based on time duration and geography.

Hertel et al. (2005), performed a review on managing virtual team's literature. Their focus was on quantitative research and they considered a continuum of virtuality rather than a dichotomous variable. They organized previous research in managing virtual teams using lifecycle model because in their opinion, different managerial tasks are essential at different stages of team development. The lifecycle model was consisted of five stages: preparation, launch, performance management, team development and disbanding. They discussed human resource issues when the virtuality of the team becomes high.

Curseu et al., (2008) reviewed the literature on information processing in virtual teams. Based on a general information processing model for teams they reviewed previous papers on the subject. They aimed to inform readers about what is known on the subject of information processing in virtual teams and to discuss the consequences of these findings for the management of virtual teams. They concluded that effective leadership can help a virtual product development team to overcome the constraints imposed by the virtual character of the communication processes and information processing.

Ale Ebrahim et al., (2009a) after reviewing the literature on virtual teams in general, identified different topics in the body of knowledge and discussed these topics in more details. These topics included different definition and types of virtual teams, some examples of virtual teams, differences between real and virtual team and challenges of virtual team. They also proposed important factors that make virtual teams effective. There were twelve factors in three categories including: factors related to people, factors related to technology and factors related to process.

In spite of these invaluable studies, the body of knowledge in the context of virtual team management needs further structure and order. Findings and insights from previous research are scattered and should be integrated into a framework. Such a framework is beneficial for identifying current theoretical gaps and recognizing unknown aspects of the phenomenon. Thus, the current study aims at categorizing the previous research on management of virtual product development teams and integrate the current body of knowledge into a thematic model that enables recommendations for future research.

3. Method

3.1. Research Criteria

In this review, we focused on managing virtual product development team. We disregarded articles focused on virtual teaming in R&D organizations and SMEs² which are dealing with the process of virtual product development. We considered studies that were concerned with both virtual product development teams and their management or at least offered some insight about the management of these teams.

Empirical and qualitative research, conceptual papers, experiences, reports and explorative case studies were considered in this paper. We disregarded papers which were not related to our purpose. For each study, we examined purpose, key findings and contribution to the field.

3.2. Research Method

We used different sources to find the relevant papers to the subject of study. We used different databases like Scopus and EBSCO on-line database system. We also used Google Scholar, Science Direct and Business Science Premier. Searching keywords contained: 1) virtual team, 2) product development, 3) managing virtual team, 4) virtual product

² Small and Medium Enterprises

development and 5) virtual R&D. Moreover, we searched through the references and citations of review papers.

Besides, we focused on 15 journals related to the virtual product development teams, and collected as many papers as possible from different databases and resources regardless of the quality of the papers. We enlisted all the possible studies to search for the complete literature. We found 65 articles which were related to product development and virtual team. These articles were published after 1999. It seems that the maturity of IT industry and Internet based telecommunication is the main cause of the introduction of virtual team as a concept and the research interest in this area. Figure 1 shows the number of articles published each year since 1999 until April 2014. Except for 2002, the trend shows approximately constant interest in the subject from 1999 to 2014 with an average of 5 articles each year.

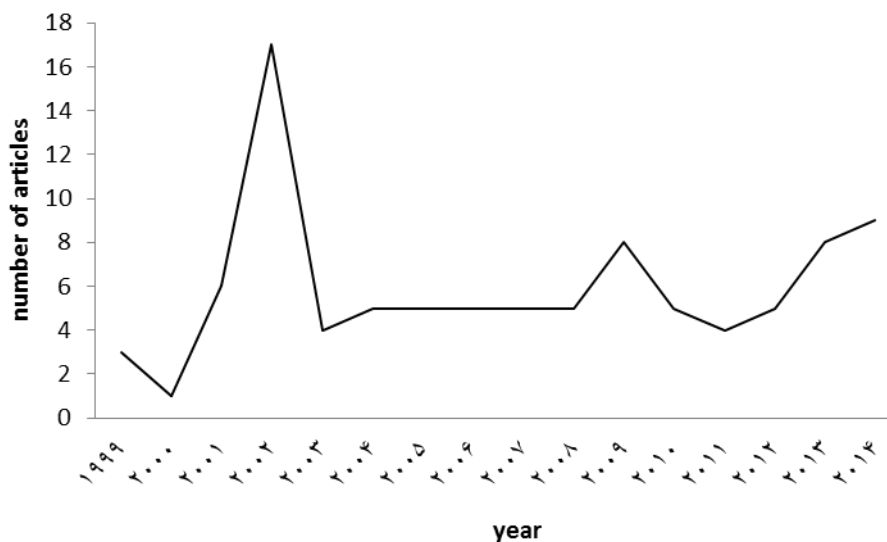


Figure 1. Number of publications on virtual team and product development

In the next step, we selected those articles which discussed virtual team management. Finally, the number of the relevant papers reduced to 22 papers. Table.2 shows a complete list of included papers and their specifications.

Table 2. Complete list of included papers and their specifications

Authors (year)	Objective	Methodology/ approach	contribution
Tuma, 1998	Clarifying the important role of virtual production	conceptual	Formulate important question in virtual production from the view point of transaction cost and production science
Schmidt, 2001	comparing the effectiveness of face-to-face teams with virtual teams in decision making in product development	Mixed method, qualitative and quantitative	He suggests the most effective decisions are made by virtual teams.
Füller et al., 2007	Demonstrating how customers can become a member of new product development team	conceptual	They introduce virtual customer integration as a new means of new product development
Bosch-Sijtsema	knowledge transfer in	Case study	They propose a framework for

Authors (year)	Objective	Methodology/ approach	contribution
& Rispens, 2003	virtual teams through a social network approach		communication in virtual teams using social network approach to facilitate knowledge transfer
Ale Ebrahim et al., 2009b	Discussing the role of virtual teams in facilitating transnational innovation processes	conceptual	They clarify the role of networks in organizations
Powell et al., 2004	Integrate the body of knowledge in the field of virtual team	Review	They categorize research based on time duration and geography and also on the basis of variables which were the focus of research. Four categories were proposed
Riedl et al., 2014	Studying the effect of members' personal traits on virtual team's innovative performance	Quantitative, regression	They offer some insights for management about the personal traits of team members.
Strang, 2011	Investigating the effect of transactional leadership and leader substitutes on increasing virtual new product development performance	Survey-quantitative	He suggests that transactional leadership and some personality attributes increase the time performance and also project scope quality.
Ale Ebrahim et al., 2012	Presenting a solution based on the popular Stage-Gate system for virtual product development team	conceptual	They propose a modified Stage-Gate system(a method of managing product development process) to cope up with the necessities of virtual team product development
Hertel et al., 2005	classifying the key activities in the lifecycle of virtual team management	review	They propose a lifecycle model to integrate literature
Al Ebrahim et al., 2009c	Exploring the role of virtual teams in SMEs competitive flexibility	review	They show gaps in the literature
Gassmann & Zedtwitz, 2003	identifying how virtual team for R&D projects across multiple locations are organized	Qualitative, interview	Propose four distinct forms of virtual team organizations
Furst et al., 2004	Identifying important factors in virtual team effectiveness	Longitudinal study, mixed method	They state that different factors are important in different stages of the life cycle of virtual product development teams and team management should consider different factors at different stages
Curseu et al. 2008	impacts of Information processing on the effectiveness of virtual teams	Systematic review	They propose a model of information processing to integrated body of knowledge
Muethel et al., 2012	Identifying the role of trust in team effectiveness	Quantitative, regression	They suggest that trust is a critical factor in virtual product development teams and

Authors (year)	Objective	Methodology/ approach	contribution
			geographic dispersion increases its impact on team effectiveness
Allen et al., 2008	Discussing the use of the virtual organization framework in managing collaboration in a mixed software team	conceptual	They propose a specific set of techniques in management of team
Economist Intelligence Unit, 2009	Seeking to provide insights into the prevalence, and management of virtual teams in European business	survey	Proposes some insights on how these teams are recruited and managed in reality
Letaief et al., 2006	Studying creativity and the creation process in global virtual product development teams	Case study	They introduce five inhibiting and four enforcing factors for innovation in Virtual global teams and propose seven stages in their creation process
Dekker et al., 2008	Identifying important factors in effectiveness of global virtual teams	Quantitative/regression	He proposes some important factors in team effectiveness and some mediator and moderator factors
Ale Ebrahim et al., 2008	Clarifying virtual R&D teams' characteristics	conceptual	They suggest some potential values of virtual R&D team and propose some guide lines for practice
Ubaka, 2010	Identifying multicultural effects in global virtual teams	Exploratory, interview	He develops a concept to be used in eliminating communication problems in global virtual team
Ale Ebrahim et al., 2010	Integrating research on Virtual R&D in SMEs and outlining structure and dynamics of virtual collaboration in SMEs	review	They suggest that effective management can help a virtual R&D teams in SMEs to overcome the constraints imposed by applying virtual R&D teams

4. Result

It is clear that there is a lack of an integrated framework for unifying different features of virtual teams and different approaches to this subject. A unified framework is necessary to organize the body of research and help in identifying the theoretical gap and the direction of future research. So, a deep literature review and examining the fragmented researches about virtual teams and product development revealed that the previous researches were mainly concerned with three phenomena: (1) Virtual production and virtual team in product development; (2) Managing virtual team in R&D and product development (3) Managing global virtual product development teams and their effectiveness.

This section proposes an interpretation of main papers. For each paper, the main idea is highlighted and the results are summarized.

4.1. First research stream: Virtual production and virtual team in product development

The first area of research concentrates on virtual production and using virtual teams in developing virtual products which create value for consumers.

The main question in this research stream is how virtual production is formed and how different players for attaining a common goal that is developing new products and services

form network relationships with each other. For example Tuma (1998) emphasized on configuration and coordination of virtual production networks, and stated that virtual production or virtual enterprise plays an increasingly important role. He mentioned that the idea of virtual production is to implement modern management trends like "concentration on core competencies", distributed production and maximum customer orientation by the application of advanced computer and telecommunication systems and services like global networking. Taking into account Williamson's theory of transactions costs, he suggested that virtual production can be interpreted as a certain kind of intermediate organizational form between two institutional poles contain market and hierarchical structured enterprises. According to this theory, an evaluation will be given on the basis of transaction costs. Tuma formulated structural and process-orientated questions of virtual production systems. Finally, he stated that the characteristics of virtual production systems imply the application of decentralized approaches.

Schmidt (2001), using escalation of commitment theory, compared the effectiveness of individuals and decision making of face-to-face teams in product development, with virtual teams. Findings suggested that virtual teams make more effective decisions than individuals in the process of product development.

Füller et al. (2005) concentrated on the question how to integrate members of virtual communities into new product development team. They stated that although online consumer groups represent a large pool of product know-how and seem to be a promising source of innovation, yet little is known about how to utilize this know-how for new product development. So they explained how to identify and have access to online communities and how to interact with its members in order to get valuable input for new product development. In this approach, they coined the term "Community Based Innovation". The Audi case illustrated the applicability of the method and underscored the innovative capability of consumers encountered in virtual communities.

Uschold&Callahan (2007) unified knowledge and product data and concentrated on semantics-based virtual product models. They were concerned with applying semantics-based technologies to enhance product development capability, including data, processes and tools, to make it faster and cheaper to design and deliver new products in which fundamental behaviors and failure modes are well understood and predictable. The main contribution of them was the presentation of a conceptual framework for understanding this goal and setting a research agenda for achieving this goal.

Bosch-Sijtsema&Rispen (2003) concentrated on facilitating knowledge transfer in virtual team through a social network approach. They argued that due to geographical dispersion and high use of information technology in virtual settings, face-to-face communication and therefore transfer of knowledge is more difficult in virtual teams. Virtual teams are characterized by geographical dispersion, use of IT for communications, members who have little history, organizational and cultural heterogeneity and weak relationships. In this regard, they developed a theoretical framework with the use of a case study and social network approach was applied to stimulate communication, and hence, the transfer of knowledge in different knowledge areas. They found that by applying a social network approach and evaluating and re-using the data with the virtual team members the communication structure within the dispersed team became clearer. Furthermore, two types of knowledge transfer were stimulated as follow: organizational knowledge transfer and task knowledge transfer, in this regard, how to organize a virtual team and how to solve a problem. Furthermore, it was found that the social context which includes trust and friendship facilitates knowledge transfer.

Ale Ebrahim et al. (2009a) argued the role of virtual teams in facilitating transnational innovation processes. They started with the positive effect of innovation in corporate performance, also mentioned that a virtual network structure is used to improve communication and coordination, and encouraged the mutual sharing of inter-organizational resources and competencies. To be more exact, 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. By contrast, in a virtual organization, 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 for individuals involved with the innovation project.

Strang (2011) focused on factors that have impact on virtual new product development projects. He analyzed leadership, personality, and organizational factors and measured their combined effect on virtual product development team's time and scope-quality performance. The findings showed transactional leadership (not transformational) and some personality attributes (leader substitutes) were significant factors, increasing virtual new product development project scope quality and time performance.

4.2. Second research stream: Managing virtual team in R&D and product development

This section focuses on different perspectives, namely conceptual and practical frameworks in managing virtual teams in R&D and product development and factors affecting this process. The main idea and results of these researches are shown in this section.

As stated earlier in this paper, Hertel et al. (2005) reviewed the empirical research in the field of managing virtual teams. They suggest a lifecycle model of virtual team management and classify the key activities in the lifecycle of virtual team management in 5 phases. Phase A is preparations, which include personnel selection and diversity, task design, task types, task interdependencies, reward systems, technology and integration of all of these into the organizational context. phase B is launching and phase C is performance management, which include leadership, electronic performance monitoring, management by objectives and feedbacks, self-managing teams, regulation of communication and conflict management, fitness of communication media for communication content, non-job-related communication, maintenance of motivation and good emotion, motivation and trust, team identification and team cohesion, satisfaction of team members, knowledge management. Phase D is training and team development, while Phase E is disbanding and re-integration. Finally, they suggest more general principles for the management of virtual teams as follow: Careful implementation of efficient communication and collaboration processes that prevent misunderstandings and conflict escalation; A strong need for clarified team goals and team roles that are not in conflict with commitments to other work units; Continuous support of team awareness, informal communication, and sharing of socio-emotional cues, sufficient performance feedback and information about the individual working situation of each virtual team member; Creating experiences of interdependence within the team in order to compensate the feeling of disconnectedness, for instance via goal setting, task design, or team-based incentives; And developing appropriate kick-off workshops and team training concepts to prepare and support the teams for the specific challenges of virtual teamwork.

Ale Ebrahim et al. (2009b) presented literature review of virtual R&D team management in small and medium enterprises. They provide a comprehensive review on this field and assess the status of the literature. They mention some of the main advantages and also disadvantages associated with virtual teaming and suggest that although virtual teams in SMEs can enhance

the competitive flexibility of organizations, there are still considerable gaps in virtual R&D team management in SMEs. According to their consideration, managing virtual R&D teams in SMEs is a challenge. Some of the important challenges are development of trust among team members, determining the appropriate task technology and establishing proper tools and systems to facilitate information sharing. Effective management can help virtual R&D teams in SMEs to overcome the constraints imposed by virtual R&D team. Setting-up an infrastructure for virtual R&D team in SMEs requires a large amount of engineering efforts, especially designing a proper collaborative system. Successful management of virtual teams requires new methods of supervision.

Gassmann & Zedtwitz (2003) reviewed the trends and determinants of managing virtual R&D teams. Based on 204 interviews with R&D directors and project managers in 37 technology-intensive multinational companies they identified four distinct forms of virtual team organization used to execute R&D projects across multiple locations. Ordered by increasing degree of project coordination, these four team concepts are based on: (1) decentralized self-organization, (2) a system integrator as a coordinator, (3) a core team as a system architect, and (4) a centralized venture team. Their contingency approach for organizing a transnational R&D project is based on four principal determinants: (1) the type of innovation (radical/incremental), (2) the systemic nature of the project (systemic/autonomous), (3) the mode of knowledge involved (tacit/explicit), and (4) the degree of resource bundling (complementary/redundant). According to their analysis, the success of virtual team management depends on the appropriate consideration of these determinants.

Furst et al., (2004) concentrated on managing the life cycle of virtual product development teams. To understand the factors that contribute to virtual product development team effectiveness in its life cycle, they tracked six virtual project teams in a large food distribution company from inception to project delivery. They identified factors at each stage of the virtual product development team life cycle that affected team performance. These factors include: interventions at the forming stage, interventions at the storming stage, and interventions at the norming stage.

They listed managerial interventions during virtual product development team life cycle as follow:

- Realistic virtual project team previews
- Coaching from experienced team members
- Developing a shared understanding and sense of team identity
- Developing a clear mission
- Acquiring senior manager support

Their results provided specific guidelines for what managers can do at various points in time to increase a virtual product development team's chance to be fully developed and contribute to firm performance.

Curseu et al. (2007) provided an overview of the most relevant factors that influence the effectiveness of virtual teams, which is information processing by virtual teams. They aimed to inform readers about what is known on the subject of information processing in virtual teams and to discuss the consequences of these findings for the management of virtual teams. They concluded that effective leadership can help a virtual product development team to overcome the constraints imposed by the virtual character of the communication processes and information processing. They pointed out because of the difficulty of setting norms in virtual product development team leaders should stimulate team members to develop norms

that guide communication such as timely information sharing and appropriate responses to electronic communication. This will also foster the development of trust in virtual teams.

Kimball (1997) introduced a new management mindset and new management style for managing virtual product development teams. She argued that there are some critical aspects of a virtual team manager's mindset that must shift in order to be effective in contemporary organizations because of several reasons. First of all, different kinds of environments can support high quality interaction. What matters is how a virtual product development manager uses them. Also collaboration happens in an ongoing, limitless-unlimited way. Furthermore, using technology in a people-oriented way is possible and desirable. When the communication process breaks down, evaluation of management and interaction strategies became technical tools. Learning to manage virtual teams is about understanding more about teams and the collaboration process.

She also mentioned some new management style and argued that managing a virtual product development team requires all the finesse and skill of managing a meeting or project. She listed some of the key ideas to have a new style to make sure a virtual team works effectively:

- Teamwork is fundamentally social and knowledge is integrated in the lifecycle of team so it needs to be made explicit
- It's important to create ways for team members to experience membership
- knowledge depends on engagement in practice, people gain knowledge from observation and participation
- engagement is inseparable from empowerment
- failure to perform is often the result of exclusion from the process

Allen et al. (2008) proposed the use of the virtual organization framework in managing collaboration in a mixed team of software agents and humans aided by such agents. They argued that this framework facilitates an integrated management approach and sets the scene for experimental work to demonstrate the effectiveness of the approach. They suggested the use of a specific set of techniques for managing the hybrid-agent teams. They described this set of techniques — the switching model, problem decomposition, negotiation, and coordination — and sketched how they can be used in concert to provide this management. The great advantage of their approach is its flexibility. The switching model is explicitly provided for switching dynamically between satisfiers and the negotiation and coordination mechanisms, similarly, can respond to changing circumstances.

Economist Intelligence Unit (2009) extracted a report about taking a more strategic approach in managing virtual product development teams. Some of the key strategic approaches for managing virtual teams are highlighted as follow:

- Common understanding of targets, procedures and the fun involved in achieving the set goals.
- Setting clear, measurable and achievable goals and carefully monitoring progress towards the goals until achievement
- The scope for misunderstanding in virtual environments is wide, therefore, actions should never be taken on the basis of assumptions
- Rapport is critical and it takes time to build rapport and an understanding between people.
- It is important to avoid using full-time teleworkers. Virtual team members should be part of a team, not only for support and morale, but also to be included in the organization's culture
- Setting expectations and communicating along the way are critical

- Managers need to set clear rules for communication, for example by setting an e-mail response time of 24 hours. Compliance with the rules needs to be constantly monitored.
- Communications (Communication) tools need to be carefully selected, taking into account cultural and gender preferences
- In putting a group of new team members together, one of the things needed to be done is to provide clarity in terms of what they will be doing as a team.
- When selecting team members, it is useful to conduct at least one interview using the technology the team member will be expected to use on a day-to-day basis. Of course, affinity with communications technology should not be the main deciding factor.

4.3. Third research stream: Managing global virtual product development teams and their effectiveness

This section concentrates on global virtual teams which are growing rapidly. The main idea of this research stream is that global virtual teams are technology mediated groups of people in various places around the world that work together on common tasks and this makes them to challenge with various issues. In this situation, cultural differences in global virtual teams are so challenging and pose a lot of communicating challenges. This area of research takes into account the role of managers in making these global teams effective. Management deals with some sort of administrative activities within a team that facilitate relationships and collaboration despite the difficulties posed by cultural differences. In this research area Letaief et al., (2003) focused on creativity and the creation process in global virtual product development teams. They studied the creation process in global virtual teams and determined factors that may increase or reduce their creativity. They conducted a case study on the intercultural virtual projects and product development teams and recognized seven stages in their creation process, namely: preparation, incubation, generation, emanation, selection, finalization, and evaluation. The creation process is illustrated as successive interactions between the team members, both conscious and subconscious. This study has uncovered nine inhibiting factors of creativity, including: dominance, domain knowledge, external rewards, time pressures, downward norm setting, structured approach, technical problems, lack of shared understanding, and non-stimulating team members. Also enhancing factors include: stimulating colleagues, a variety of social influences, example setting, a collaborative climate, and team members who make mistakes. They mentioned these factors can interfere with the creation process and influence the global virtual product development team's creativity.

Dekker (2008) emphasized on behaviors in global virtual teams, the processes of trust and social presence, the role of the input variables: isolation and national culture, and the outcome variables: team satisfaction and team performance. He recognized those behaviors which are critical for the effectiveness of global virtual teams, and stated that it is important to know these behaviors among team members because they transform inputs into outcomes in global virtual teams. He categorized the critical interaction behaviors as: use of media, handling diversity, interaction volume, in-role behavior, structuring of meeting, reliable interaction, active participation, including team members, task progress communication, extra-role behavior, sharing by leader, attendance, and social-emotional communication. He also takes cultural differences into account for the effectiveness of global virtual teams. He mentioned that virtual team members working in various national cultures differ with respect to what behaviors they view to be important for the effectiveness of global virtual teams. Because global virtual teams are, by definition, dealing with various national cultures, it is important

that people involved take into account the importance of knowing situational differences in global virtual teams. When team members are not aware of other team members' situation, they might wrongly make dispositional attributions which will most likely negatively influence the collaboration in the future.

Ale Ebrahim et al. (2008) deal with virtual product teams in new product development. They state that national and global collaboration in research and development and product development is increasingly important. The knowledge created through these collaborations makes the business more competitive. They mention that multinational enterprises have increased their researches and develop their investment in different countries; these multiple sites encourage the development of more ideas, due to the virtual product teams in new product development. They suggest that virtual teams are important mechanisms for organizations seeking to control scarce resources across geographic and other boundaries. Moreover, virtual collaboration has become vital for most organizations in the context of designing new products and innovative services. So, in light of this importance they discuss all the major aspects of virtual product development and provide an integral definition and characterization of virtual product development team.

Ubaka (2010) dealt with multicultural effects based on communication challenges encountered in global multicultural virtual teams. His goal was initially to generate the best possible idea or concept that will support effective communication in a global virtual team. The idea was generated during the conceptualization stage of his thesis. The main objective was to integrate virtual communication systems to fulfill the user demand in eliminating the problems of multicultural global virtual product development teams.

4.4. Summary of the main studies in each field

As argued in previous section, research in managing virtual product development teams' area is categorized in three fields. The first field of research concentrates on virtual production and virtual team dealing with developing of products which create value for consumers. The second field of research focuses on different perspectives including conceptual and practical frameworks in managing virtual teams in R&D and product development. It also deals with factors affecting this process. The last field of research concentrates on global virtual teams which are growing rapidly. The main studies in each field of research are shown in table 3.

Table 3. Summary of main researches in each stream

	Year	Researcher	Main Idea
First research stream	1998	Tuma	<ul style="list-style-type: none"> • configuration and coordination of virtual production networks • virtual production or virtual enterprise plays an increasingly important role
	2001	Schmidt	<ul style="list-style-type: none"> • Using commitment theory, compared the effectiveness of decision making of individuals in face-to-face teams with virtual teams
	2007	Füller et al	<ul style="list-style-type: none"> • Integration of members of virtual communities into new product development team • online Consumer groups represent a large pool of product know-how and seem to be a promising source of innovation
	2007	Uschold & Callahan	<ul style="list-style-type: none"> • unifying knowledge and product data, concentrated on semantics-based virtual product models • presentation of a conceptual framework for understanding semantics-based virtual product models • Setting a research agenda for achieving semantics-based virtual product models
	2003	Bosch-Sijtsema & Rispens	<ul style="list-style-type: none"> • facilitating knowledge transfer in virtual teams trough a social network approach • by applying a social network approach and evaluating and re-using the data by the virtual team members the communication structure within the dispersed team became clearer

	Year	Researcher	Main Idea
			<ul style="list-style-type: none"> • two types of knowledge transfer: organizational knowledge transfer and task knowledge transfer
	2009a	Ale Ebrahim et al	<ul style="list-style-type: none"> • the role of virtual teams in facilitating transnational innovation processes • the positive effect of innovation on corporate performance • virtual network structure is used to improve communication and coordination and encourage the mutual sharing of inter-organizational resources and competencies
	2010	Strang	<ul style="list-style-type: none"> • factors that have impact on virtual new product development projects • transactional leadership and leader substitutes are significant factors, increasing virtual new product development project scope quality and time performance
	2011	Skageby	<ul style="list-style-type: none"> • introduced and explored cycles of pre-produsage and produsage of virtual products
Second research stream	2005	Hertel et al	<ul style="list-style-type: none"> • reviewing the current empirical research in field of managing virtual teams • suggesting a lifecycle model of virtual team management and classified the key activities in the lifecycle of virtual team management in 5 phases
	2009b	Ale Ebrahim et al	<ul style="list-style-type: none"> • presenting literature review of virtual R&D teams' management in small and medium enterprises • mentioning some of the main advantage and also disadvantages associated with virtual teaming • although virtual teams in SMEs can enhance the competitive flexibility of organizations, there are still considerable gaps in virtual R&D team management within SMEs
	2003	Gassmann & Zedtwitz	<ul style="list-style-type: none"> • reviewing the trends and determinants of managing virtual R&D teams • identifying four distinct forms of virtual team organization used to execute R&D projects across multiple locations
	2004	Furst et al.	<ul style="list-style-type: none"> • concentrating on managing the life cycle of virtual product development teams • identifying factors at each stage of the virtual product development team life cycle that affect team performance
	2008	Curseu et al	<ul style="list-style-type: none"> • Information processing by virtual teams influences the effectiveness of virtual teams, • effective leadership can help a virtual product development teams to overcome the constraints imposed by the virtual character of the communication processes and information processing
	1997	Kimball	<ul style="list-style-type: none"> • Introducing a new management mind set • Introducing new management style for managing virtual product development teams
	2008	Allen et al	<ul style="list-style-type: none"> • propose the use of the virtual organization framework in managing collaboration in a mixed team of software agents and humans aided by such agents • suggesting the use of a specific set of techniques for managing the hybrid-agent teams that support the operation of coalition forces
	2009	Economist Intelligence Unit	<ul style="list-style-type: none"> • taking a strategic approach in managing virtual product development teams • introducing some key strategic approaches for managing virtual teams
Third research stream	2006	Letaief et al	<ul style="list-style-type: none"> • focusing on creativity and the creation process in global virtual product development teams • uncovering nine inhibiting factors of creativity • uncovering enhancing factors of creativity • recognizing seven stages in global virtual product development team creation process
	2008	Dekker et al	<ul style="list-style-type: none"> • emphasizing on behaviors in global virtual teams • emphasizing on the processes, trust and social presence, the role of the input variables: isolation and national culture, • Emphasizing on the outcome variables: team satisfaction and team performance
	2008	Ale Ebrahim et	<ul style="list-style-type: none"> • dealing with virtual product teams in new product development

Year	Researcher	Main Idea
	al	<ul style="list-style-type: none"> • multinational enterprises have developed investment in different countries which encourage the development of more ideas in new virtual product development teams
2010	Ubaka	<ul style="list-style-type: none"> • Multicultural effect in global virtual teams based on communication challenges encountered in a multicultural global virtual teams

4.5. Thematic Map of Domain of Managing Virtual Product Development Teams

After providing the background of research in the field of virtual product development teams and summarizing previous studies in three major fields of research, a thematic map in area of managing virtual product development teams is now introduced as a visual aid for showing the structure and sequence of research. This map is designed to organize the previous studies in this field of research.

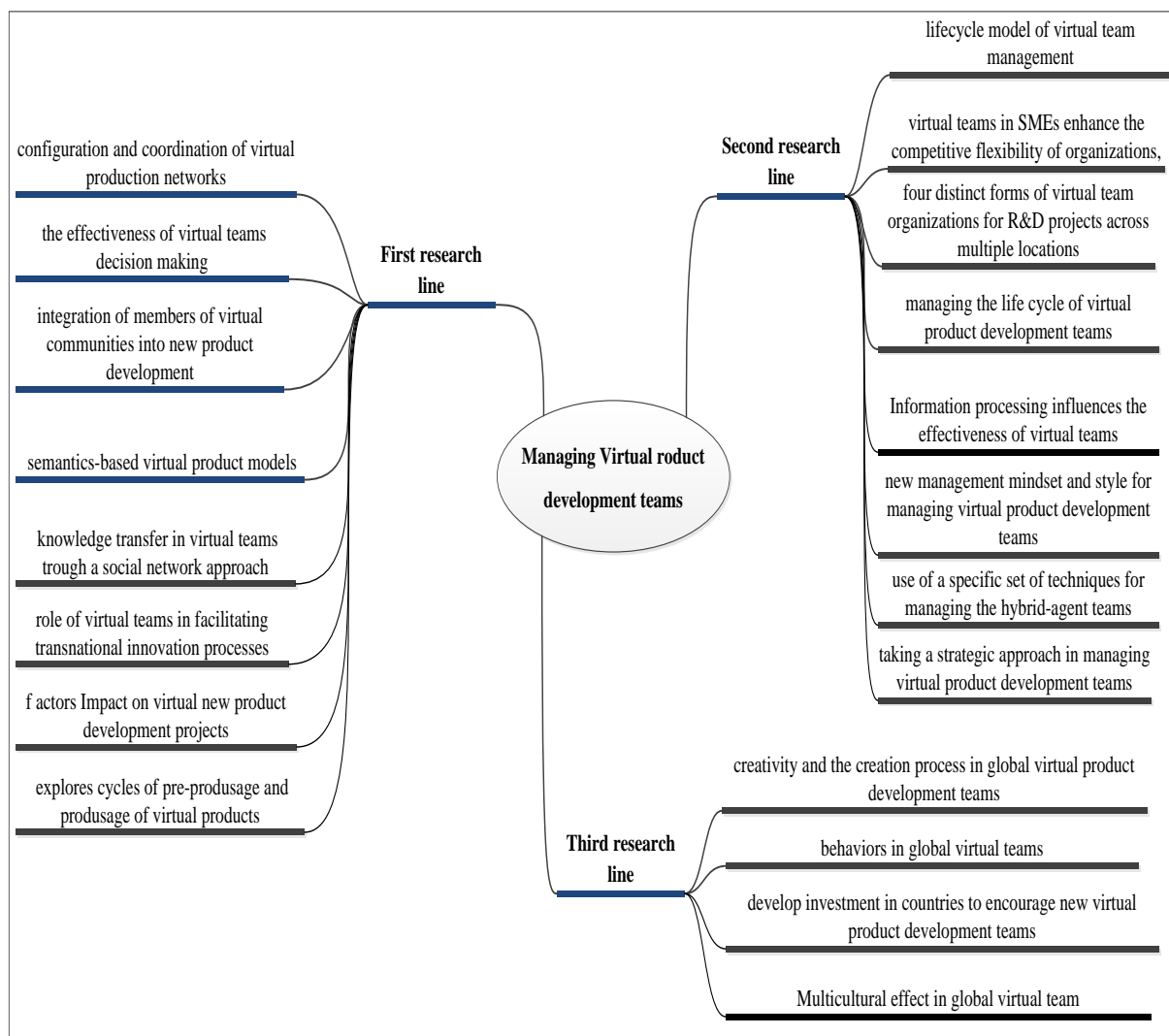


Figure 2. Thematic Map of the Domain of Managing Virtual Product Development Teams

5. Recommendations for Future Research

Despite the fact that a fairly large body of literature in the field of virtual product development teams and their management has evolved in recent years, many questions

concerning these fields have remained unanswered. Many aspects of the phenomenon are still unknown. The following recommendations should be considered in future research in this area:

First, there is a need for more qualitative and exploratory research in this field. The process in which a virtual product development team is shaped and operates could be explained by qualitative methods using real data. Identifying this process and important factors influencing its function can provide some insight on how this process should be managed.

Second, comparative analysis of a virtual team and a face to face team working on a (the) same project could be fruitful. Different scenarios like change in the planning, change in the strategy and change in management and their consequences on the performance and adaptation of the teams could be analyzed. The result would have useful implications for virtual product development team management such as how flexible the planning and strategies should be and how change could be managed in virtual teams.

Third, successful cases in virtual product development teams should be the subject of deep inquiries. Exploratory research should investigate how these teams have overcome difficulties in building trust among team members, how they have set goals and defined roles and how they have overcome difficulties related to communication and collaboration. Successful teams could provide some useful insight for management of virtual teams.

Forth, studying unsuccessful virtual product development teams could be advantageous too. Previous research indicates that virtual product development teams fail more often than they succeed (Furst et al., 2004). It is important to know what the similar features in these failed projects are. What is the bottleneck in virtual product development team? Comparing failed project at different stages could show critical factors in success of virtual product development teams and factors' relative importance compared to each other.

Fifth, another question that remains unanswered is that what kind of project the virtual product development team is more suitable for. Maybe for some kind of products virtual product development team is the best choice which reduce cost and time of development , but for some kind of products virtual team doesn't work. Further research is needed to answer such questions.

6. Conclusion

The main objectives of this review were to summarize the previous researches on the subject of management of virtual product development teams, in order to integrate these researches into a thematic model. Results showed that previous researches were mainly concerned with three phenomena: (1) Virtual production and virtual team in product development; (2) Managing virtual team in R&D and product development (3) Managing global virtual product development teams and their effectiveness.

The first area of research concentrates on virtual production and using virtual teams in developing products which create value for consumers. The main question in this research stream is how virtual production is formed and how different players for attaining a common goal that is developing new products and services form network relationships with each other. Papers in the second field of research focus on different perspectives namely conceptual and practical frameworks in managing virtual teams in R&D and product development and factors affecting this process.

The last field of research concentrates on global virtual teams which are growing rapidly. The main idea of this research stream is that global virtual teams are technology mediated groups of people in various places around the world that work together on common tasks and this makes them challenge with various issues. Previous research has addressed many important

issues such as difficulties in goal setting and role definition in virtual teams, difficulties with building trust among team members, implementation and management of communication processes.

In this study by reviewing the literature five implications for future research are elaborated. More qualitative and exploratory research is needed in this area of research. The process in which a virtual product development team is shaped and operates could be explained by qualitative methods using real data. Comparative analysis of a virtual team and a face to face team working on the same project could be fruitful. Furthermore, successful cases in virtual product development teams should be the subject of deep inquiries. Successful teams could provide some useful insight for management of virtual teams. Also, studying unsuccessful virtual product development teams could be advantageous too. Previous research has neglected the unsuccessful virtual product development teams. It is important to know what the bottleneck in virtual product development team is. Another question that remains unanswered is that what kind of project the virtual product development team is more suitable for. In sum virtual product development team is rather a new area of research and many questions in this field remains unanswered. This review aimed at clarifying the subject and classifying the current body of knowledge in the field which could guide the future research endeavors.

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