Global product development: an attempt at harmonising the research effort

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Abstract
More companies are increasingly globalising activities throughout the product development process, from R&D to manufacturing. This presents companies with both technical and organisational challenges. These are addressed in different theoretical areas, in particular within Engineering Design & Development, Organizational Studies, and Operations Management. These research areas all contribute different insights into how the global product development process can be viewed, understood and analysed.

This paper overviews current research in these research areas and illustrates that by creating a synthesis which utilizes the empirical insights and theories from these areas, a more holistic picture can be painted of global product development.

Keywords: Globalisation, Global product development, Cross-disciplinary

Introduction
Companies are increasingly globalising their engineering activities through global networking alliances, and by moving tasks to engineering facilities offshore (Chiesa, 2000). The first process is termed "offshore outsourcing", and the latter "offshoring". We use both terms when debating engineering globalisation.

These global engineering operations have led to new challenges, including cultural differences, time zone differences, knowledge transfer, employee retention, and intellectual property protection (Rottman & Lacity, 2008). Few companies know how to evaluate the risks associated with moving functions and tasks offshore (Kumar, *et al.*, 2009). The resultant literature shows a lack of synthesis across research areas due to a lack of a cross-disciplinary approach. This paper addresses this gap by showing that greater insight into the underlying processes of global product development (GPD) can be gained by combining research conducted in three different academic fields (Engineering Design & Development, Organizational Studies and Operations

Management). The Global Decision Making (GDM) framework is shown as a first attempt at creating such a synthesis of the current research.

Research approach

This paper presents a literature review of how global product development has been approached in three different theoretical fields; Operations Management, Engineering Design & Development, and Organisational Studies. Each of these fields have devleoped new knowledge and insights into the increasingly global product development process, from a network perspective (e.g. Minshall, 1999; Zhang & Gregory, 2011) to offshore design centres (e.g. Eppinger, 2006; Eppinger & Chitkara, 2006), over outsourcing phases and risk evaluations (Perunovic, 2009; Stringefellow *et al.*, 2008) to cultural issues and organisational studies (e.g. Nielsen *et al.*, 2008; Chen *et al.*, 2010).

Hereafter, a summary of the conclusions from these different fields will be created in order to show how these can be used to complement each other and thereby gain a synthesis of the research effort within global product development. Finally, a discussion of utilizing a cross-disciplinary approach is presented.

Operations Management

Network-based organisation structures and coordination mechanisms are emerging to address issues in managing dispersed business activities. Network organisations are characterised by horizontal patterns of exchange, interdependent flows of resources, and reciprocal lines of communication (Koka *et al*., 2006). In a network, transactions occur neither through discrete exchanges nor by administrative orders, but through the network of individuals engaged in reciprocal, preferential, and mutually supportive actions (Hakansson *et al*., 2009).

Engineering network concepts have been developed in knowledge domains such as global product development, international R&D, global innovation and international manufacturing. Examples include the matrix structures which have been adopted in engineering operations to improve the performance of project teams, as well as maintaining leading expertise at a functional or regional level (Eppinger & Chitkara, 2006).

Concepts like concurrent engineering (Backhouse & Brookes, 1996), collaborative engineering (Willaelt *et al*., 1998), centres of excellence (Reger, 2004), and virtual teams (Powell *et al*., 2004), have been adopted to develop new products/services more quickly and less costly with global resources.

International R&D and innovation networks have been proposed as a strategy to support the market or to access technologies/expertise on a global scale (Von Zedtwitz *et al*., 2002). Global manufacturing networks have been researched extensively in recent years and from many different angles like network design, network capabilities, and the network performance (Kyläheiko & Sandström, 2007).

In light of this theoretical context, global engineering networks (GEN) have been developed to address the increasing dispersion of engineering activities across geographical and ownership boundaries.

The *characteristics* of effective engineering networks were first identified by Zhang *et al*. (2007; 2008). These were aspects of global engineering operations, engineering knowledge management, networked resources, and IT support and integration.

Zhang *et al*. (2008) also revealed the *evolutionary trends* towards global engineering networks by investigating the major drivers, main barriers, organisational

features, and performance preferences. They proposed a systematic approach to understanding global engineering networks through investigating their contextual features, critical capabilities to success in a contextual circumstance, and configuration characteristics to deliver the capabilities (Zhang *et al*.,2007).

The essential elements of global engineering networks have been summarised with the context-capability-configuration (3Cs) framework, i.e. the GEN framework, which is embedded in the strategic management theories and the operations management literature, especially the contingency theories (Sousa & Voss 2008), the configuration theories (Boyer *et al*., 2000), and the theories of organizational or operational capabilities (Voss, 2005). The GEN framework suggests a systematic approach to understanding global engineering networks through investigating their contextual features, critical capabilities to compete in a particular contextual circumstance, and configuration characteristics to deliver the capabilities (Zhang *et al*., 2007).

The above studies contribute to an overall understanding of engineering offshoring issues in the current business environment. According to (Zhang *et al*., 2008) the three key missions of global engineering networks are to 1. Gain global efficiency, 2. Develop innovative products/services and 3. Improve strategic flexibility. The four main network capability areas that can achieve the above missions are (Zhang *et al*., 2007) 1. Communication & sharing, 2. Integration & synergising, 3.Innovation & learning and 4. Adaptation & restructuring

GEN also suggested a configuration view to systematically describe the organisational features of engineering network operations from the following five configuration perspectives shown in table 1 (Zhang & Gregory, 2011).

Table 1 - Configuration perspectives (Zhang & Gregory, 2011)

Configuration	Description
Network structures	Physical resource footprint, including the size, number, types/roles of network members, and the network design rationale.
Operations processes	Flow of material and information between network members to create customer outputs.
Governance systems	Mechanisms to direct and control the network, including authority structures, performance measurement, and coordination mechanisms.
Support infrastructure	Enablers for network members to work together, including information systems, tools, resources, cultures, and behaviours.
External relationships	Interaction with external partners, including suppliers, customers, users and collaborators

Engineering Design & Development

Research into GPD started in the 1990s and is still a relatively new discipline. Research has focused on identifying the main risks. These include cultural differences, time zone differences, knowledge transfer, employee retention, and intellectual property protection (Rottman & Lacity, 2008). Studies show that unsuccessful knowledge transfer is one of the principal reasons for failure in globalisation endeavours (Carmel & Beulen, 2005). Culture is a big risk factor as it influences communication, quality, knowledge sharing, and many other management aspects (Kull & Wacker, 2010).

A Danish survey (2004) uncovered the main barriers to offshoring experienced by Danish companies, which included communication difficulties, cultural differences, unforeseen costs, large travel costs and internal opposition. Offshoring-specific risks include managing local staff and local market needs, culture, and organisational risks (Lord & Ranft, 2000).

Research has also focused on identifying the reasons for these complications. Stringefellow *et al.* (2008) argued that the reason lies in the interaction intensity and interaction distance between the company and the organisational unit. Interaction intensity consists of service content and service process. Interaction distance is based on the distance between cultures, languages and geographical distance. By evaluating the degree of interaction distance and interaction intensity, a company can evaluate whether to move a given task to a given location. Manufacturing companies which offshore high-level engineering tasks like product development, product design and R&D activities to low-cost countries create a situation in which there is a high degree of interaction intensity. This emphasises the risks involved with engineering offshoring.

There has however, been little research within Engineering Design & Development about how to address these risks. Eppinger (2006) created a list of best practices based on empirical studies for global design and development. One of the main frameworks which have been developed comes from global manufacturing. The Global Footprint Strategy of Manufacturing is a model practitioners can use and have been using when globalising manufacturing activities (Minshall, 1999). It has a focus on strategy, operations, implementation, and evaluation/learning.

Organizational Studies

Organisational studies have focused on different organisational aspects of globalisation such as the transformation of organisational structures (like IT) to facilitate the relocation of production systems, and human resource aspects, such as limiting attrition rates, transferring knowledge effectively, and limiting social hardship (Nielsen *et al.*, 2008).

The outsourcing process is now well researched and many models are available. Perunovic (2009) presents an overview of seven such models which he combines to create his own model. This model he calls the Outsourcing Circle. It is a five-stage cyclic model which not only considers what to outsource but includes the full range of outsourcing dilemmas. The five stages are: 1. Preparation, 2. Vendor(s) selection, 3. Transition, 4. Managing relationship and 5. Reconsideration. The last stage, reconsideration, can mean the arrangement can change or be dissolved. While most offshoring and outsourcing arrangements start due to cost saving, over a period of time they change to a knowledge gain and later even a strategic focus (Maskell *et al.*, 2007).

Outsourcing decisions can be explained using four different theoretical perspectives (Tsang, 2000); 1. Transaction cost economics, 2. Relational exchange theory, 3. Resource-based view and 4. Resource dependency theory. While these theories can explain different aspects of the reasons for GPD, many companies have today globalised throughout their product development process for different reasons. This encourages a cross-disciplinary approach to the reasons for GPD which allows for the use of several theoretical lenses within the same company.

An organisation can have many structural formats. These include bureaucracy, matrix, functional, divisional, virtual, team, and project based. Morgan (1986) used eight metaphors to describe the organisation of companies, for example machine, brain and organism. The organisational structure is assumed to influence how offshoring and outsourcing of the product development process is carried out as it creates the boundaries where this process must take place.

Culture affects all aspects of communication and human interaction, including how to transfer knowledge. The cultural aspects of communication, knowledge sharing, leadership, organisational structures, and other aspects of the organisation are all

affected when a company globalises product development process activities and it is therefore a relevant area to consider (Schneider & Barsoux, 2002).

Internal opposition to outsourcing or offshoring – one of the main problems companies often encounter - can be caused by ill preparation. If outsourcing and offshoring is considered a change management project, then internal opposition can be explained using this framework (Palvia, 1995). How to manage organisational change from a planned change perspective has been illustrated by many different authors, for example in Kotter's (1996) eight step model of planned change. This is in line with the research by Yip *et al.* (1988) on the global company, underlines the fact that company's which use a global strategy must also concurrently have a global culture, processes, structure and people which are all key elements to adapt during a change management process. Outsourcing and offshoring activities from the product development process will change power which will lead to some people benefitting from the change, and others losing, which could motivate resistance or support for the change.

A company works towards a certain goal when outsourcing/offshoring product development process activities. Cybernetics is an example of a cross-disciplinary approach for exploring regulatory systems like organisations, their structures, constraints, and possibilities. The cybernetic model uses control to identify and adjust for any differences between desired and individual and organisational performance.
Control processes include: 1. Set organisational goals as part of an overall strategic plan for the organisation, 2. Set work targets or standards at each level of the organisation, 3. Monitor performance (individual and group) against these targets and 4. Assess the result of these measurements and correct any deviations.

The cybernetic model is flexible and can involve as detailed or as high level control and monitoring as is suited for the culture, organisation and situation in question (Wiener, 1948).

Offshoring or outsourcing often has far reaching consequences on knowledge creation, sharing and retention – also within the units which remain in the original location as these have to learn, grow and share together with the offshored or outsourced units. Knowledge management research shows that developing, exploiting and transferring knowledge across organisational units is critical for success (Gupta & Govindarajan, 2000). A major challenge is to manage local knowledge integration (Saka, 2004). Chen *et al.* (2010) showed that knowledge tacitness, knowledge gaps, cultural and communication difficulties and weak relationships were the critical barriers in cross-cultural knowledge transfer, which is confirmed by other researchers (Vianello & Ahmed, 2012).

This review shows that while different aspects of global product development have been investigated from organisational angles no unifying frameworks have been developed for the area. Furthermore, it shows that there are several theories in organisational studies which can be used to understand GPD, an area that has not received great attention and not well researched.

An attempt at synthesis

Complex situations arise when companies globalise there product development process, which can be explained by using different theories, models and approaches. The three different theoretical approaches each provide unique insights into global product development and design. Operations management provides case studies and theory regarding networks and the interconnectivity of a global organisation. Engineering Design & Development are focused on case studies within global design and development and focuses on the changes that have to take place on the micro-level to

make a global engineering project successful. Organisational studies provide the connection to the rest of the organisation and the softer issues which are needed to make a global organisation succeed like change management and culture which affects people and their behaviour. In this manner the different research approaches compliments each other and provides the opportunity to view challenges within global product development from different angles and thus create a more thorough and holistic solution which considers both network, organisational, technical and human resource aspects. We therefore propose that by attempting a synthesis of these different perspectives on the global product development process, a more holistic approach to the research area can be created which enriches both these three research fields and practitioners.
By using synthesis analysis allows the complexity of globalising the product development process to be addressed in greater detail.

This complexity can be due to the added interconnectivity globalisation brings to the external and the internal environment in which the organisation operates. Across the different academic fields, some common features regarding the globalisation of the development process can be identified.

1. External environment where globalisation has to take place:
    - Drivers for globalising product development process activities.
    - Barriers for globalising product development process activities.
    - Specific industry conditions.
2. Internal environment where globalisation has to take place:
    - Organisational structures.
    - Organisational culture.
    - Decision making.
    - Control and monitoring of processes in the organisation.
    - Change management projects.
    - Engineering characteristics include product and product development process modularity.
3. Spanning both the external and internal environment:
    - Networks.
    - Culture.
    - Knowledge management.

The literature review has identified there are four sequential stages a company experiences when globalising the product development process.
It also identified that the company needs to follow a clear strategic plan and send more value-adding tasks offshore as it learns to control the globalisation process. Cybernetics can be one way to ensure the company is moving towards the desired goal by measuring outputs and initiating correcting actions.

Engineering companies often start their globalisation process with manufacturing. Few companies have a clear strategy for their manufacturing networks; they are often an outcome of mergers and acquisitions and organic growth. The outcome of such event can also occur when engineering and R&D services are moved offshore. Thus, a company needs to clarify their network configuration to create the most advantageous network.

Motivations to globalise product development vary, but usually fall within three categories; 1. Cost savings, 2. To gain access to competences and 3. To gain access to markets.

The literature review also identified that companies encounter several barriers when moving tasks offshore. These barriers include communication difficulties, unforeseen costs, internal opposition, collaboration, IP rights, learning and knowledge management, quality, managing organisational change and management control. One of the biggest influences has been culture.

These challenges can be analysed using different aspects of organisational theory, knowledge management and network configuration in operations management. By using each theoretical framework on different aspects of the company's globalisation of the product development process it is assumed a more holistic picture of the companies' actions can be described.

Globalising product development is an organisational change which makes it relevant to include theories from change management.

Knowledge management is vital in order to complete and coordinate tasks. The type of knowledge needed where and when, how and in what format become important issues. Furthermore, using more than one approach and tool when transferring knowledge which varies depending on context, will likely be most successful. This includes the role of expatriates in knowledge transfer and generation.

A global company creates networks with internal and external actors through formal and informal networks made up of individuals. Using the GEN framework on the engineering networks created through offshoring and outsourcing additional insight into the reasons for complications with GPD process can be found through exploring five facets of the network configuration 1. Network Structure, 2. Operations Flow, 3. Governance and Coordination, 4. Support Infrastructure and 5. Product Configuration.
Research has mainly focused on minimising risk and reducing complexity by avoiding certain high risk situations. The ideal situation is therefore one where there is low task complexity and high organisational complexity. This includes low interaction distance and low interaction intensity to minimize cultural difference and communication. Process and product modularity is needed to ensure a clear separation of tasks and processes and thus minimise interaction. There is a focus on low complexity products and functions in what is sent offshore.

However, today when companies globalise elements from the whole product development process complexity may be unavoidable, indicating a need for a framework which can address the risks and challenges in the GPD process. Furthermore, the linkage between manufacturing and other activities like design and R&D have often been a surprise for many companies; indicating even tasks which may be considered less complex may be harder to move offshore than first anticipated.

By creating a synthesis which utilizes the empirical insights and theories from three research disciplines, a more holistic picture can be painted of the challenges engineering companies experience in relation to globalisation of product development process activities and how these can be addressed.

Reflections

This paper proposes that research within global product development should be cross-disciplinary and that practitioners need to combine methods from different theoretical fields in order to gain a holistic perspective, and minimize the risks associated with in this discipline area. This can be compared to the organisational paradigms proposed by Morgan (1986). The organisation needs to view and analyse global product development activities from different fields, or paradigms. In this way practitioners can create a more holistic perspective and ensure that challenges of an operational, technical, organisational and managerial nature have been considered. Research within

global product development could utilize the synthesis between three research fields in order to validate, expand and refine theories and methods.

Furthermore, a guide or method similar to the Global Footprint Strategy (Minshall, 1999) could be created which combines academic insights with industry research and presents it in a comprehensive model for use in industry. A first attempt at this was done with the Global Decision Making (GDM) framework (Hansen &Ahmed-Kristensen, 2011). The GDM framework consists of five iterative stages: (1) Strategic goal setting, (2) Strategic planning (3) Operational planning, (4) Implementation phases and (5) Evaluation. The GDM framework utilizes methods and theories from these three academic fields, supported by empirical data. The GDM framework is part of a guide created for Danish Industry to companies on how to globalise the product development process. However, the GDM framework needs to be further validated and the choice of methods and theories used from the three theoretical fields need to be further researched, elaborated and validated.

Conclusion

Global product development is researched from different theoretical angles, including Engineering Design and Development, Organizational Studies, and Operations Management. In this paper we propose that a more holistic picture of this research area may be seen by taking a cross-disciplinary approach to the global product development process. Practitioners and researchers should therefore focus on a cross-disciplinary approach in order to build on the synthesis created from these three different theoretical perspectives.

Further research is needed to investigate which models and theories within the three theoretical fields are most important for a company to employ and how the different theories affect each other and the solution. It also needs to be investigated whether any additional research areas can further improve the solution space for global product development.

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