ADDRESSING THE RISKS OF GLOBAL PRODUCT DEVELOPMENT

Hansen, Z.N.L. & Ahmed-Kristensen, S.

ABSTRACT

Offshoring various stages in the product development process – from engineering tasks like R&D and design to manufacturing activities - can impact the development process, the product and the organisation. Some of these impacts are positive while some are negative. The negative impacts are related to rework, misunderstandings, miscommunication and lower quality. This paper investigates how the organisation can reduce the negative aspects of offshoring by presenting two possible approaches; one which lessens the exposure to situations in which these negative impacts happen and another which addresses them in the decision phase so the organisation can develop appropriate strategies for these instances.

Keywords: Organisation, product development, offshoring, knowledge, case study

1. INTRODUCTION TO GLOBAL PRODUCT DEVELOPMENT

Technological advancements in telecommunications, expansion of the European Union and open borders in the Far East and Eastern Europe has created the possibility for global expansion for large as well as small and medium sized companies. Motivators are often cost reductions, market access or to gain new competences. Outsourcing is the movement of a task or activity previously done in-house to outside providers. Offshoring is the movement of a task or activity to the company's own overseas facilities [1]. This paper focuses on offshoring to own facilities abroad and to strategic partners in low-cost countries. Today almost any organisational function from customer service and payroll management to hardware production and R&D engineering can be moved to low-cost countries.

However, case studies have shown that companies often encounter hidden costs when offshoring and outsourcing such as interaction intensity and interaction distance [2]. These are related to the degree of communication, interaction and the distance between cultures. In this paper we address these negative aspects of global product development and illustrate possible ways they can be resolved.

We first present a literature review of global product development, introduce the empirical method and present the findings. Thereafter a discussion of the findings is given followed by the conclusion.

Global product development started with the offshoring wave in the 1990s and has since grown [3]. It is therefore still a relatively new development. Changes in market, technology and market preference have led to companies seeking to reduce development costs, improve development quality, and shorten development time [4-5]. This is increasingly happening by globalising product development. Today a majority of manufacturing companies offshore not only production but also large parts of their product development process, including R&D activities [6,7]. The key difference between conventional and global product development is the increased reliance on virtual collaboration across time zones and cultures in global product development [3].

Many companies move from offshoring simple tasks to gradually offshoring more complex tasks like new global products. According to Eppinger this development is a clear strategic move [3].

Frequently encountered problems in outsourcing include cultural differences, time zone differences, knowledge transfer, employee retention, and intellectual property protection [8, 9].

In a survey by the organization for Danish Executives[1] the main barriers Danish companies encountered when outsourcing were uncovered. The most significant were communication difficulties, cultural differences, unforeseen costs, large travel costs and internal opposition to outsourcing [10]. Low quality was also mentioned as a barrier [11]. These challenges also seem relevant to offshoring. Challenges specific to offshoring include managing local staff and markets, culture, and organisational challenges alike those seen in other restructuring and change management projects [12]. Organisational challenges include knowing what knowledge needs to be transferred and how the

[1] Translated from the Danish title "Ledernes Hovedorganisation" by the authors

communication and collaboration is to be managed. This includes the difference in engineering practices between cultures as well how to organise the transfer.
Developing, exploiting and transferring knowledge across organizational units is critical for the success of global corporations and has been shown to be a key challenge in offshoring and outsourcing of engineering tasks [13]. A major challenge of transferring knowledge in multinational corporations is to manage local knowledge integration [14]. It has been shown that knowledge tacitness, knowledge gaps, cultural and communication difficulties and weak relationships were the critical barriers to successful knowledge transfer using a structured knowledge transfer process in a cross-cultural knowledge transfer context [15].
Eppinger lists 10 success factors for global product development; 1) Management priority, 2) Process modularity so work packages can be segregated, 3) Product modularity so interfaces can be clearly defined, 4) Core competences are identified, 5) Intellectual property is identified, 6) Data quality so one system or database is a 'source of truth' for all the globally disbursed teams, 7) High standard of infrastructure and other technical equipment, 8) Governance and project management to coordinate and manage the projects, 9) Need for a collaborative culture and 10) Organisational change management is needed to plan, train and educate staff [3]. These factors focus on the technical aspect of the product as well as managerial aspects in terms of controlling the process to ensure quality and IP rights. The coordination issue is focused on the technical tools as the overall assumption for these success factors seem to be a development process controlled and managed by the headquarters through modularity.
This paper presents a solution for practitioners when they engage in global product development. The research aim is to suggest an approach to global product development which can address the difficulties companies have when moving engineering tasks abroad.

2. RESEARCH APPROACH

The nature of the research suggested a case study approach due to the explorative nature of an area wherein unknown factors and elements are sought [16]. Multiple case studies were used to be able to make comparisons and to distance the researcher. For consistency, all companies were large international corporations with headquarters and ownership in Denmark.
The primary data source was semi-structured interviews; structured questions were asked but the interviewer was open for new information. There was little or no documentation available in the companies, which meant the interviews were the primary data source. The questions were related to issues seen as causing complexity, which tools were used to reach greater transparency and the observed implications – all of these issues seen in relation to knowledge transformation. Not all interviewees were asked all the questions as some were only relevant for certain groups. All the interviews lasted 50-70 minutes, and were audio recorded, transcribed and analysed. For analysis, a coding scheme was developed. The codes were based on a literature study whenever possible or derived from the dataset. In total 22 codes were used. Table 1 shows the codes and their definition.

Table 1. Coding scheme used in this study

No.	Categories	Definition
1	Interviewee	The identity of the interviewee
2	Company	The identity of the company
3	Overall reference frame	Whether the statement is a current or desired future state
4	Offshoring	Whether the statement was in relation to offshoring
5	Outsourcing	Whether the statement was in relation to outsourcing
6	Motivation	The motivation to move abroad
7	Involvement in decision process	Which stakeholders were involved in the decision to offshore or outsource
8	Issues debated during the decision process	Key issues which were relevant in the decision process
9	Contact with the outsourcing supplier/subsidiary	How the company kept in contact with the outsourcing supplier or the subsidiary
10	Positive experiences of offshoring or outsourcing	The positive experiences the interviewee had had with offshoring or outsourcing
11	Negative experiences of	The negative experiences the interviewee had had with

	offshoring and outsourcing	offshoring or outsourcing
12	Choosing suppliers	The motivation for choosing a supplier
13	What functions to move abroad	What the interviewees felt was important in order to be able to move a function successfully abroad
14	Unforeseen issues	Unforeseen issues the company had when they had offshored or outsourced
15	Culture	Cultural differences the company encountered
16	Product features	The changes the company did to the product development process to counteract perceived difficulties
17	Development process	The changes the company did to the product development process to counteract perceived difficulties
18	Knowledge gain due to offshoring or outsourcing	Whether there was a knowledge gain by moving abroad
19	Knowledge transfer type	The type of knowledge the interviewee is addressing
20	Moving from offshoring to outsourcing	The reason the company moved from offshoring to outsourcing
21	Moving from outsourcing to offshoring	The reason the company moved from outsourcing to offshoring
22	Future strategic approach to outsourcing and offshoring	How offshoring and/or outsourcing will be handled in the future

The coding scheme was applied to the transcribed interviews, classifying each sentence/segment to each code in the scheme. This allowed for categorisation of important terms and situations.

3. INDUSTRIAL CASE STUDIES

This section introduces the case companies and the findings in relation to the impact of offshoring and outsourcing and the actions the companies took to address negative impacts.

3.1 Introduction to the case companies

The findings are based on case studies of five Danish multinationals with production and development activities in Eastern Europe, India, or China, and target markets in Europe, North America, and the emerging economies in the Far East and Eastern Europe. Table 2 illustrates the characteristics of the case companies. Some interviewees were interviewed more than once to clarify information gained in the first interview. The cases were selected to obtain a breadth in the dataset across sectors and sizes.
35 interviews with top managers and vice presidents were conducted, audio recorded, transcribed, and analysed. The variety of interviewee positions enabled a multifaceted view of the research focus.

Table 2. Characteristics of the case companies

Company synonym[2]	**Industry sector**	**Country & process**	**Interviewees' position & amount**
X1	Telecommunication manufacturer	Offshoring of engineering to China Outsourcing of production to China Outsourcing of embedded IT to India	Vice presidents, managers 4 interviewees
X2	Equipment and service to the raw materials sector	Offshoring of engineering and R&D to India and USA	Vice presidents, managers 11 interviewees
X3	Engineering consultancy within pharma and biotech	Offshoring of engineering to China	Managers 12 interviewees
X4	Service and equipment to the energy sector	Offshoring of engineering to China	Managers 3 interviewees

[2] All case companies are given synonyms to respect their wish for anonymity

X5	Electronics and mechanical manufacturer	Offshoring of production and engineering to China	CEO and vice presidents 5 interviewees

Most of the case companies developed a similar globalising process; no matter if this was applied to their own facilities (offshoring) or foreign suppliers (outsourcing). The pattern observed was first manufacturing was offshored and then the other phases followed, effectively going backwards in the product development process.

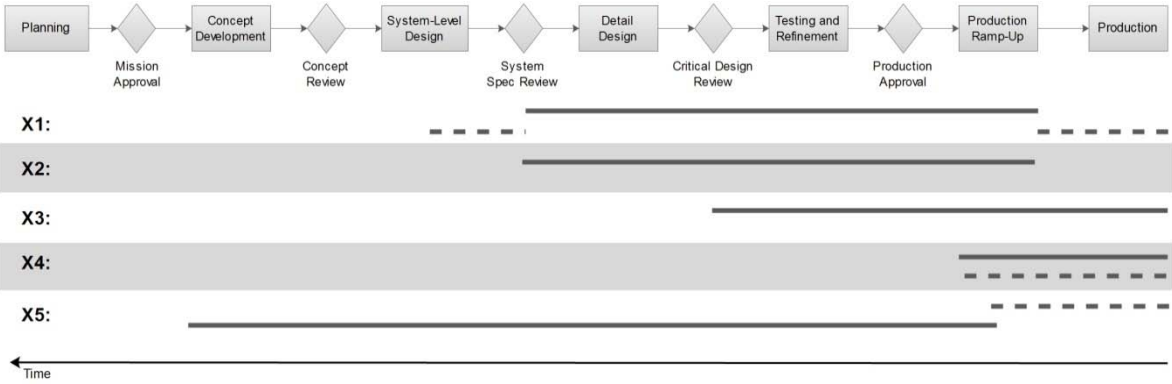

Figure 1. Company details (outsourcing marked by dotted line, offshoring with a full line)

As can be seen in figure 1 which compares the companies' offshoring and outsourcing activities to the generic product development process model [17], X1 first offshored all of production, parts of production ramp-up, testing and refinement, detailed design, then outsourced all of embedded IT, offshored parts of the system level design and finally outsourced all of production. X2 outsourced all of production, parts of ramp-up and testing and offshored design and development for product changes to the Chinese office. X3 offshored parts of production, ramp-up, testing and refinement and design and development of local market products. X4 was a small company which outsourced all of production, ramp-up, and low level design. After being acquired by a large multinational cooperation, X4 offshored instead. X5 outsourced all production and bought a company in the USA to do R&D assignments for the American market. The subsidiary in India had grown over the years and now handles R&D, design and development tasks for both the local and global market. Today more than 75% of all engineering tasks for X5 are handled by the Indian office.
All the case companies had a very brief preparation phase before the decision to move anything abroad was taken. The motivation to offshore for the case companies was a combination of factors, but mainly cost reductions, local competiveness, and being close to the market.

3.2 Impact of offshoring and outsourcing

The case companies experienced both desired and undesired impact from offshoring and outsourcing on the organisation, the product development process and the product itself (see table 3).
Desired impacts were related to the motivations for moving abroad as well as the complexity of the product and its development and production. Undesired impact factors were time and quality.

Table 3. Findings related to impact

Functional area	**Desired impact factors**	**Adhoc desired impact factors**	**Undesired impact factors**
Product development process	Improve the process	Reduce complexity in the process	Lower quality
	Lower overall costs		Increased rework
	Reach local markets		Delays
The product	Increased functionality	Increased product portfolio	Lower quality
		Reduce complexity in the product	Reduced functionality
The organisation	No visible effects		Misunderstandings in communication

			Coordination difficulties
			Increased resources on knowledge sharing, communication and coordination

These impacts were related to the increasing complexity of the product development process mainly due to cultural differences and virtual collaboration. Cultural difference meant differences in communication, leadership, organisation, design methods, market needs and knowledge sharing. Complications caused by virtual collaboration included virtual coordination of knowledge and information across cultures. Virtual collaboration and coordination was made more difficult as not everyone could be informed at the same time and there was no opportunity for informal discussion.

3.3 Actions to address the negative impacts

The negative impacts of global product development came as a surprise for all the case companies. As a consequence, the process of globalising product development was seen as a 'learning by doing' experience. The case companies initiated actions to address these negative impacts. It was an adhoc decentralized process where each manager and engineer would implement the actions he or she thought would best address the given problem. The actions observed to address the negative impact on the product, development process and the organisation are illustrated in detail in the following.

1) Adopting codification as an approach to knowledge transfer.

To reduce the negative impacts, many of the case companies made communication between the Danish headquarters and the foreign office more explicit. This was to avoid quality issues and delays caused by misunderstandings and minimize cultural differences, as common and specified documentation was believed to ease complexity. Documenting knowledge and processes gave the possibility to review and improve these processes.

2) Making the product development process more explicit.

Contact and information sharing initiatives were mainly from the Danish headquarters to the foreign office on a manager level; there was no direct contact to the engineers conducting the work. This information exchange predominantly focused upon status reports, handing over new tasks and sharing documented procedures and work flow descriptions developed in the headquarters. Ensuring tasks are self-contained therefore lead to decomposition of the development process.

3) Creating a more simple product design.

A complicated design, employing many mechanical or other specific parts is harder to communicate and debate virtually and across cultures when the engineers also come from a different educational culture. In the cases were gaining competences was not one of the main motivating factors to offshore or outsource, in order to reduce risks the complexity of the products designed abroad was limited and design methods and approaches known to engineers in both the headquarters and the foreign office were employed. This was believed to lessen issues with culture and information sharing. Furthermore, the case companies found it easier to share information and knowledge on a simplified product, task and process as it was easier, describe and document in detail. An example from X1 was that the product sent abroad for development was technically complex. The solution was to lower complexity, in this case by having less complex mechanical parts. Furthermore, some of the Danish engineers had a lack of trust in the capabilities of the foreign engineers which this approach also addressed.

4) Bridging distance between design and production.

Some of the companies attempted to bring design and production back into close contact and in this way avoid cultural misunderstandings and delays and misinformation in communication. Several of the case companies therefore moved more development and design tasks abroad once they had moved production to ensure production and design engineers again were in close contact. However, this had not been planned when the company when they first decided to move abroad.

5) More quality checks.

To improve quality detailed procedures which had to be followed in regard to security and quality checks of the engineering and production work produced abroad were developed. While these procedures would catch many of the flaws, they also required additional resources and time.

6) Training.

Training of the foreign engineers happened by bringing a few engineers to the Danish headquarters for some months to work. In this manner they would learn both the company's work processes and the Danish organisational culture by working in the headquarters.

3.4 Complications

Implementing these adhoc control actions was not without risks and difficulties. Therefore, the case companies continued to feel negative impact factors from their increasingly global product development process. This could indicate the control actions attempted to avoid the areas which created difficulties but didn't resolve them.

The difficulties the companies encountered are described in the following.

1) Adopting codification as an approach to knowledge transfer.

The company often had to spend more time and cost on creating new and updating existing documentation. Furthermore, not all information and knowledge could be documented which made it difficult to employ the solution in all cases. The companies were not always aware of how much knowledge was tied in routines and organisational culture (e.g. implicit and tacit knowledge) and which could therefore not easily be transformed into explicit knowledge. In other words, the cost of knowledge transformation and the possibility of capturing all information when conducting such a transformation to explicit knowledge were first discovered when the companies attempted to codify their processes and communication.

2) Creating a more simple product design.

Simplification of the design of the product could have both positive and negative impacts. On the positive side it could save time and resources by reaching the same goal in a simpler way. However, a risk was that the product could lose some of its functionality and lose appeal to certain markets.

3) Bridging distance between design and production

Unexpectedly moving higher value adding functions abroad could impact the value chain in waysthe company had not foreseen, some of which could be negative. Furthermore, it could merely move the problem and not solve it (e.g. so instead of a problem between design and production it could be between R&D and design).

4) More security and quality checks.

This took up more time and resources and the additional security checks could prevent or slow knowledge transfer.

5) Training.

Having engineers visit was expensive and an unforeseen expense. It took up more time and resources and knowledge transfer processes between colleagues did not seem to function as efficiently as hoped for both in the headquarters and when the engineer returned home. It was furthermore difficult to ensure the trained engineer was retained in the company after the training was completed.

4. DISCUSSION AND PERSPECTIVES

The findings showed that globalising product development through offshoring or outsourcing impacts the product, the development process and the organisation both positively and negatively and that adhoc solutions to address the negative impacts did not fully remove them.

4.1 Reasons for complications

The case companies had only considered the positive impacts of moving abroad so very few processes were in place to handle problems and difficulties. The control actions were adhoc solutions to the unexpected negative impacts. The overall fitness and consequence of implementing the control actions to counteract the negative impact factors on the product, the product development process and the organisation had not been evaluated.

These findings suggest that the characteristics of the organisation, the goal with offshoring or outsourcing, product features and other characteristics seem to influence the fitness of a solution meant to counter the negative impacts. For example, if the task sent abroad needs a high degree of interaction this might be difficult to compensate for solely through documentation. We therefore propose two different approaches to address the negative impact of global product development which considers these factors.

4.2 Two approaches

Globalising product development therefore seems to require considerations not just related to the organisation but specific to the technical aspects of the product and the product development process. The company can take two approaches;

1) Minimizing the chance of negative impact factors by limiting the tasks and functions considered for offshoring
2) Minimizing the chance of negative impact factors through considering the technical and organisational aspects of offshoring

Neither approach can ensure no negative impacts are felt as the causes will remain (e.g. cultural differences and virtual collaboration) but the effects of them can be reduced.

In the first approach the company can attempt to avoid situations which can cause difficulties by limiting the tasks and functions considered for offshoring. This means minimizing interaction and situations which requires complex explanations. To facilitate this, the company can, before offshoring or outsourcing a task, consider three key areas; the product, the process and the organisation as shown in table 4.

Table 4. Key areas to clarify before moving out

The product	Maturity of the product affected by offshoring. ➢ A more mature product is likely to require less interaction.
	The product design ➢ A design which uses detailed design methods known to all the globally disbursed engineers and a simple setup with few complexities (for example a low level of interacting mechanical parts) is easier to send abroad as it requires less explanation and knowledge sharing.
The development process	The product development process model used. ➢ The more interaction required the greater likelihood of the negative impacts related to miscommunication and misunderstandings.
	Interconnectivity of the task aka interfaces ➢ If the task is not dependant on input and knowledge from many sources (e.g. customers, other departments, suppliers) it is easier to separate a clearly defined task which has limited interaction with other parts of the product development process.
The organisation	The company's history with offshoring. ➢ Experience with offshoring would bring awareness of possible negative impacts such as coordination, communication and culture and the success of previously implemented control actions to counteract these.
	The communication cultures of the units involved. ➢ If these are different this needs to be considered when deciding upon how to communicate, share information and transfer knowledge. Procedures and processes developed for communication, information and knowledge sharing therefore need to balance according to the different communication cultures.
	Available documentation and written procedures ➢ If the task considered for offshoring can be documented and the work processes detailed step by step it lessens the reliance on oral communication and a common frame of reference can be used when debating the task in later communications.

Some of these elements were mentioned in the literature review e.g. product and process modularity while some are new additions [3]. These are presented in detail in [18].

In the second approach the negative impact of offshoring and outsourcing can be addressed by considering the technical and organisational aspects of globalisation. In this manner a complex task which requires a high degree of interaction can be sent abroad. This could for example be R&D tasks, conceptual design, and embedded functionality of the product or other complex elements of product development. In this approach it is suggested that the company include both organisational and technical aspects of offshoring and outsourcing throughout the entire process; from decision to

implementation. To do so the organisation first need to clarify how the task considered for offshoring or outsourcing are structured technically and organisationally today and hereafter develop strategies for handle potential negative impacts when this task is then moved abroad. This can be done through an investigation on how the current knowledge sharing, communication and collaboration is for the engineering task the company considers sending abroad. Through such an investigation the current technical and organisational structure of the task can be uncovered. This investigation could include technical and organisation aspects such as the 7 key areas mentioned under approach 1. Hereafter further details in relation to the product, the process and organisation can be investigated as illustrated in table 5.

Table 5. Additional elements to clarify before moving out

Area	**Clarify**
Product	Requirements for the product in regard to which features could be altered and which cannot
Development process	What knowledge is needed, its format and where it is Amount of knowledge which is or can easily be documented All interfaces (e.g. input, communication) to internal and external stakeholders Communication needed between key personal for the task to be carried out successfully Likely cost of transferring knowledge which is not documented
Organisation	Likely cultural differences between the organisational units which needs to communicate
	How communication, coordination and knowledge sharing can continue virtually
	Strategic importance of task and the product and process knowledge involved in its development

The company can develop scenarios e.g. images of the future for how offshoring or outsourcing can impact the task in regard to the product, the development process and the organisation. To consider both organisational and technical aspects both engineers and managers could take part. Different management approaches to scenario development exist wherein strategic simulation and narratives are combined to include both technical and organisational aspects [19]. These scenarios could include possible impacts if for example unofficial communication was not possible, if certain knowledge isn't shared or the process knowledge is partly or fully owned by the foreign office. By illustrating through scenarios likely negative impacts of offshoring or outsourcing the task the company can initiate actions and procedures which can address these negative impacts. These could include:

1. Changing some of the interfaces if possible to better fit with global development
2. A communication plan with clear communication lines and responsibilities
3. A plan for how to move knowledge, when, to where and who has responsibility for this
4. A plan for how the collaboration can take place; the technical tools, the human factors like development of trust, educational differences and cultural considerations
5. Include key people affected by the change both in the foreign office and in the home country in creating these plans to ensure commitment, transparency and cultural consideration

This approach assumes that process modularity and product modularity cannot be reached for all tasks companies move abroad. In the case studies a key factor for failure with implementing the adhoc solutions seemed to be that they all belonged to the first approach whereas the task in question belonged to the second approach. This meant the task could not achieve full product and process modularity and hence there was not a clear division of tasks and interaction which the first approach encourages. The second approach to successful offshoring of product development presented in this paper thereby introduces an additional approach to success with global product development than the one presented by Eppinger [3]. Besides product and process modularity we propose that a thorough investigation of affected key areas within the product, the development process and the organisation

are investigated and planned for before the task is moved. In this manner tasks which are not suited for product and process modularity can still be offshored with success.
Which of these approaches to implement will depend on the organisation's characteristics, the characteristics of the task considered for offshoring or outsourcing, the strategic goal with moving abroad and the risks the organisation is willing to take. The first approach, by limiting situations which can cause the negative impact factors, also limit the way communication, knowledge sharing and collaboration can take place. The knowledge here is concerned mainly with making the product in a more efficient way so it is mainly product knowledge which is moved. Moving abroad for cost reduction and in some cases for market access could fit this approach. The second approach focuses on developing strategies for handling the negative impacts and thus allows for collaboration and interaction. This approach is needed when companies go abroad to gain new or additional competences. In this approach not just product knowledge but also process knowledge needs to be moved so the new knowledge which comes from the foreign office can be incorporated. Figure 2 illustrate this point. The first approach strives towards low risk but also little possibility for learning across the organisational units. The second approach relies on collaboration and knowledge sharing across borders by making use of synergies in cultural differences and viewing a problem from many different angles. The more process and product knowledge the organisation shares and collaborate on across borders the greater possibility for organisational learning and growth. However, the risks will also be greater because the desired learning synergies might not develop and the headquarters could risk losing control over the process knowledge they send abroad.

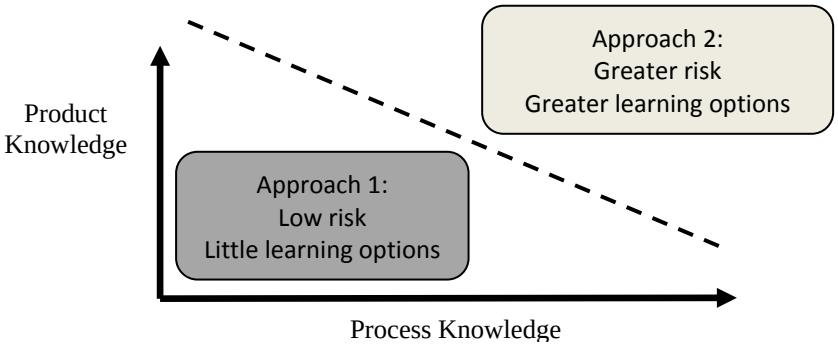

Figure 2. Risks & benefits

A company could change approach as the endeavour grows or circumstances change (e.g. changes in technology, market or organisational strategy).

5. CONCLUSIONS AND NOTES FOR FURTHER RESEARCH

Through case studies with five Danish multinationals it was discovered that global product development can impact the product, the product development process and the organisation. Some of these impacts are negative while some are positive. Companies initiate adhoc solutions to counteract the negative impacts. However, these do not always fully resolve the situation. While the negative impacts can't be avoided we suggest two different approaches in how to address them. One is meant to minimize risks and the other is meant to address them. The first limits the causes for complications; e.g. communication, collaboration and knowledge sharing, by selecting the task to send abroad according to clear criteria which include product and process modularity and detailed procedures and processes. The second approach addresses likely negative impact factors throughout the offshoring or outsourcing process – from decision to implementation. During the decision phase the company clarifies the characteristics of the organisational and technical aspects of the task which is being sent abroad and documents the interfaces and interactions it has to internal and external stakeholders. Hereafter, scenarios are developed for how offshoring or outsourcing could impact the product, the product development process and the organisation knowing it has these interfaces and characteristics. In this way changes can be made to the interfaces or other aspects of the task, if possible, or strategies can be developed to address possible negative impacts on the task due to these aspects if or when they arise. In this manner the severity of these impacts can be limited.
These results could benefit companies by illustrating how the negative impacts of global product development can be addressed through two different approaches depending on the company's strategic

goal and organisational and technical characteristics. This could help companies avoid costly mistakes, rework and misunderstandings. By considering the impact global product development has on three key elements - the organization, the product and the product development process – the technical and organisational aspects of product development can be connected and viewed in union. These results suggest changes may be needed to engineering education. Engineers may need to develop competences also in more humanistic fields related to communication and culture and managerial fields such as scenario building and strategy development.

Further research is needed to *firstly*, investigate companies in other fields than product development and other cultures to determine the influence of these parameters. *Secondly*, verify the 2 approaches in the case companies and in other organisations facing similar challenges so the two approaches can be further developed through these results. The authors plan to do this in a continued study.

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