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THE IMPACT ON THE PRODUCT DEVELOPMENT PROCESS WHEN OFFSHORING OR OUTSOURCING

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1. Introduction

Today's business environment is characterized by a short time to market, changing customer specifications, global competition, and strong demand for local price competitiveness. An effective response often involves globalisation of the product development process through outsourcing and offshoring, including both manufacturing and research & development. In the manufacturing industry, outsourcing /offshoring typically begins with the manufacturing phases, and only more recently has development followed. However, the real impact of this on the product development process is rather unknown and little investigated.

Offshoring and outsourcing occurs when "*...firms relocate their business functions (that were previously performed inhouse) to overseas locations. Firms can either embark on offshoring internally, by setting up their own centers or subsidiaries in foreign countries while maintaining full ownership and control…. or externally, by handing over business functions to independent foreign providers*" (Kedia *et al*., 2009: 250). The first is referred to as *offshoring* while the latter is called *outsourcing*. *Domestic outsourcing* is when the foreign provider is in the same country and when it is abroad it is referred to as *offshore outsourcing*. This paper only deals with *offshore outsourcing*.

Changes in the world's economy (e.g. the rise of countries like China and India), politics (e.g. the breakup of the Soviet Union) and telecommunication (e.g. the Internet) enabled fast communication and documentation sharing across vast distances. The outsourcing wave started with IT outsourcing in the 1990s, and much of the literature is focussed on IT. Offshoring, however, has a longer history. Offshoring from the USA has been said to start when Ford Motor began assembling Model T's in Trafford Park, England in 1911; in order to reduce transportation costs. The process of American companies moving labour-intensive processes to offshore locations to reduce the production costs of goods and services intended for the United States market began in the 1960s. In the late 1990s, the offshoring phenomenon spread from manufacturing to the service sector. By the turn of the millennium, offshoring services extended to high value services like IT, banking, finance, the medical field, engineering, R&D, and product design. Other western countries have followed a similar path.

The motivation to offshore or outsource is often a combination of a number of factors including the necessity to be close to customers, market access, availability of cheap labour, availability of certain competences, incentives from local governments, reducing transportation costs as well as production delivery lead times (see for example Kedia *et al.*, 2009). Cost is one of the most often cited reasons for offshoring or outsourcing business functions and activities.

Through offshoring and outsourcing product development and design has become a global activity, spanning culture and geographical location. Distributed teamwork and cross-cultural collaboration has therefore become key focus areas within design (see for example Cheng, 2003). Research into international collaboration has shown that how to best support teamwork varies across different

cultures which add a new complexity to management of distributed teamwork (see for example Kim & Bonk, 2002). Designers have also been shown to make design choices which have origins in their own culture, creating challenges for cross-cultural development teams where often also the culture of the customers play an important role (see for example Ono, 2006; Lee & Harada, 2000 and Leur *et al*, 2006).

Knowledge as a resource, an asset, is one of the motivators to offshore or outsource. Knowledge can be separated into two main categories; codified or personified knowledge. Codified knowledge can be written down, but personified knowledge is tacit and is transferred through human factors (see for example Hansen *et al.*, 1999). Knowledge in offshoring and outsourcing is about gaining new knowledge, transferring knowledge and keeping already developed knowledge inside the company under the new conditions of a global product development process. Today, few engineers stay within the same company for many years and offshoring and outsourcing can even involve layoffs of the production workers and/or engineers whose knowledge is needed abroad. Considering that knowledge transfer, retention and creation in offshoring and outsourcing situations also needs to cross spatial and cultural boundaries the complexity becomes apparent.

Manufacturing companies have a significant difference compared to IT companies, namely the high cost of production/manufacturing and the cost and lost time due to changes if development does not go according to plan. Iterative processes in IT are faster and cheaper, due to the fast development time.

Many product development models exist within manufacturing companies; the two used in this paper are the generic product development process (stage gate model) and the spiral development process as described by [Ulrich and Eppinger, 2008]. Figure 1 shows the generic product development process which has stage gates or reviews after each phase.

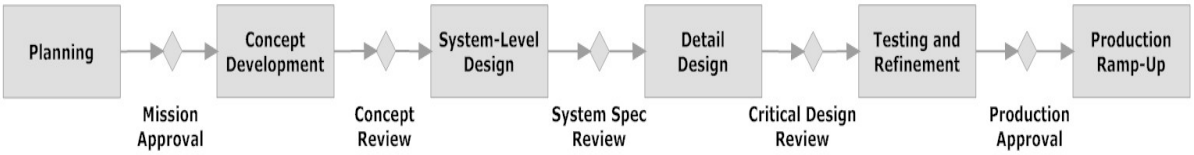

Figure 1. Generic product development process ("stage gate model"); from [Ulrich & Eppinger, 2008]

The generic development process is characterized by stages or steps with gates, indicating a division between each of these. The spiral development process is characterized by going through these steps several times (see Figure 2).

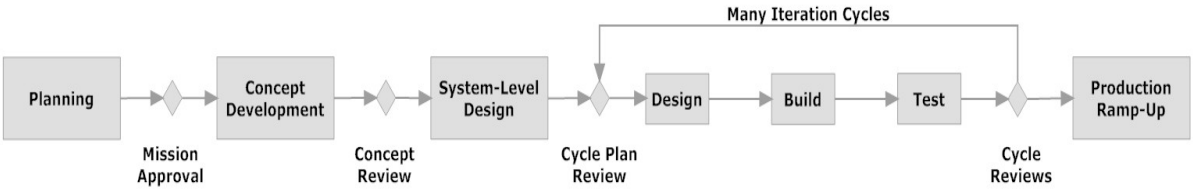

Figure 2. Spiral product development process. From Ulrich & Eppinger (2008)

The spiral product development process is common for electronic consumer goods and is characterised by an iterative process through detailed design, testing and refinement as the product is designed, built and tested to be adjusted to newly discovered needs or improvements.

When offshoring or outsourcing, a production company can focus on a business function (for example all the production of a certain product like the example from Ford Motors) or an assembly/subassembly of a product (like, for example, the gearbox in a car).

This review shows a need for further research into the connection between the outsourcing and offshoring endeavour and its impact on the product development process in hardware engineering companies, which forms the focus of this paper.

2. Aims

This paper aims to illustrate the impact on product development when a company outsources or offshores part of this process abroad. There is a lack of available literature showing the impact offshoring and outsourcing can have on the product development process, and how this impact were viewed by the companies. The specific aims of this paper are to:

1) Understand the impact of offshoring and outsourcing business functions, and parts of the product, on the construction of the product development process.
2) Investigate how this impact was handled in the case companies.
3) Illustrate possible improvements for the organisation.

The data is based upon case studies of five companies involving 20 interviews. The focus is on understanding the outsourcing and offshoring process from the motivation and preparation phase to implementation impact (see Figure 3).

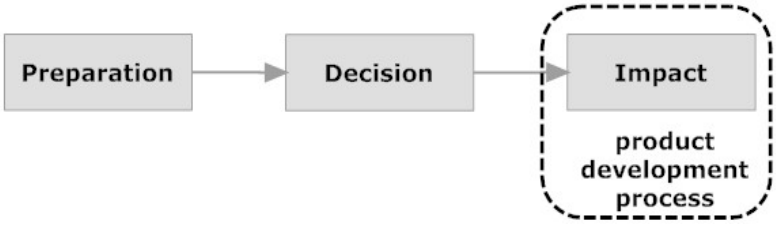

Figure 3. Focus of decision model for outsourcing/offshoring area

3. Empirical method

The nature of the research questions suggested a case study approach due to their explorative nature of an area wherein unknown factors and elements are sought (Yin, 1994). For consistency, all companies were large international corporations with headquarters and ownership in Denmark.
Table 1 illustrates the case companies with regard to type of company, choice of product development process, the position of the interviewees, and the number of interviews.

Table 1. Cases with reference to development processes as described by [Ulrich & Eppinger, 2008]

Company synonym	Type of companies	Development Process	Interviewees' company positions	Number of Interviewees
X1	Business to business (B2B) and business to consumer (B2C) telecommunication manufacturer	Spiral product development	Vice presidents	3
X2	B2C goods manufacturer	Generic product development	Vice presidents	5
X3	B2B electronics and mechanical manufacturer	Generic product development	CEO and Vice presidents	4
X4	B2B electronics and mechanical manufacturer	Spiral product development	CEO and Vice presidents	4
X5	B2B construction manufacturer	Generic product development	CEO and Vice presidents	4

By interviewing top managers in a CEO or vice president position from different departments (e.g. procurement, manufacturing, engineering, sales and marketing) a multifaceted perspective is gained. As the CEO is often the main (or sole) deciding force in regard to outsourcing and offshoring, the perspective of the vice presidents - who were responsible for implementation and the daily management - provided another approach to the topic.

4. Data collection

The primary data source was semi-structured interviews; so structured questions were asked but the interview was open for new information. There was little or no documentation available for the decisions and implementation steps taken in any of the phases of the outsourcing or offshoring process, which meant the interviews were the primary data source. The questions were related to preparation, decision making, impact and factors seen as leading to success and failure. Not all interviewees were asked all the questions as some questions were only relevant for certain groups. All the interviews lasted 50-70 minutes, and were audio recorded, transcribed and coded. The codes were based on an intense literature study whenever possible. However, as there has been little investigation into the area of outsourcing and offshoring in relation to its impact on the development process many of the codes were derived from the data. The reliability of the final coding scheme was evaluated by means of Cohen's kappa test (Cohen, 1960) and the scheme's kappa value found to be 0.99; the few remaining disagreements were resolved. Table 2 shows an example of the codes used.

Table 2. Example from the coding scheme

Categories	Codes (Subcodes)	Definition	Literature
Knowledge transfer	Type (codified, personified)	Codified knowledge can be written down while personified knowledge is tacit and is transferred through human factors	Hansen *et al.*, 1999
Unforeseen difficulties	Culture, quality, physical distance, need for codification, need for consistency in regard to codification	The difficulties the companies encountered when offshoring or outsourcing	Emerged from data
Efficiency effect of offshoring or outsourcing	More efficient processes, more efficient supply chain	The effect offshoring/outsourcing can have in regard to efficiency	Emerged from data

5. Results

The case companies had several points of similarity (see table 3). X1, X4 and X5 all offshored an entire function while X1 and X4 had outsourced an entire function. Case company X2 and X4 outsourced and then moved to offshoring instead. Case company X1 was the only company that had first offshored and then later outsourced what had been offshored.

Table 3. Characteristics of the cases

Company synonym	Outsourced and then offshored	Offshored an entire function	Offshored and then outsourced	Outsourced an entire function
X1		X	X	X
X2	X			
X3				
X4	X	X		X
X5		X		X

Most of the case companies went through the same process when offshoring/outsourcing; manufacturing was offshored or outsourced first and then the other phases followed, effectively going backwards in the development process (see figure 4). X1, X4 and X5 offshored/outsourced the entire function for the whole company (e.g. all of production) while X2 and X3 only did so for certain products/product lines or parts of a product.

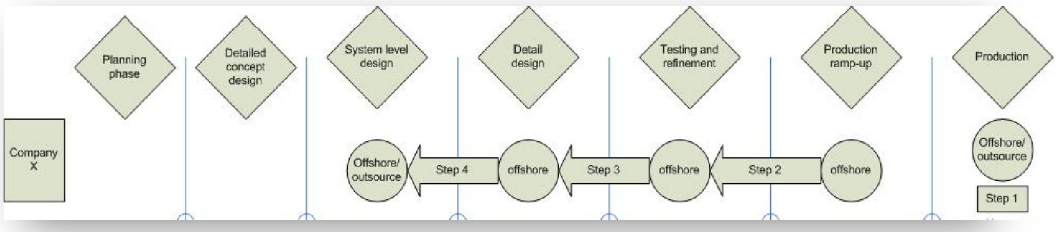

Figure 4. The case companies all started offshoring/outsourcing production and then moved backwards into the development process

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 production ramp-up and testing and refinement for new products or product changes, and finally offshored all of production. X3 offshored parts of production, production ramp-up, and then parts of testing and refinement. X4 was a small company which outsourced all of production and production ramp-up. After being brought by a large multinational cooperation, X4 offshored production instead. X5 outsourced all production from Denmark during a costcutting restructuring period from 2000-2004, first to Eastern Europe and then to China. In the 1990s X5 had brought a company which had a subsidiary in India. Over the years this office grew, and slowly, as competences were transferred, it received more knowledge-intense assignments. The Indian office now does most of the system level design and all subsequent phases up to production for all standardized products.

The following sections present results relating to:

1) Impact on the product development process when offshoring or outsourcing.
2) Control actions initiated by the case companies to handle this impact.
3) Problems with initiating these control actions.
4) How the changes brought on by offshoring or outsourcing could be used to implement improvements in the organisation.

5.1 Impact of offshoring and outsourcing on the product development process

One of the consequences of outsourcing or offshoring found in the case companies was added complexity due to cross-cultural virtual communication and collaboration. Examples given in the cases were mainly;

1) Human factors e.g. language and cultural differences making communication more complex; these heighten the importance of detailed documentation and codifying knowledge.
2) Physical distance meant shipments took longer and site visits were rarer. Furthermore, communication and knowledge transfer has to happen mainly through virtual means. This adds another dimension of complexity to the interaction.

5.2. Control actions

The controlling actions many of the case companies did to counteract this added complexity was to 1) simplify the process by simplifying the product sent abroad for development or 2) make the process more explicit (see figure 5).

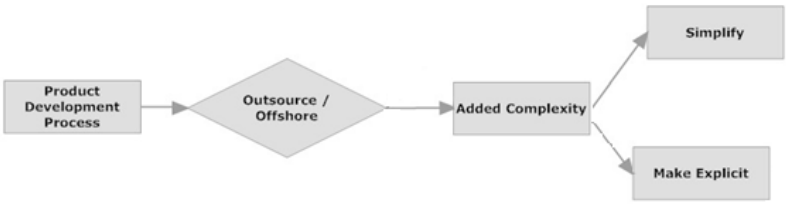

Figure 5. The empirical investigation showed the impact and actions the case companies took in regard to the product development process

1) In order to handle the added complexity the development process can become more explicit. The following control actions can be adopted to address this complexity:
    a) Documentation needs to be detailed and be kept up to date.
    b) The company needs to be aware before offshoring or outsourcing whether or not their processes can be documented or if most knowledge is personified. If the latter is the case, outsourcing is difficult due to differences in organisational culture and therefore different views on why, how and when to transfer knowledge.
    c) A spiral product development process is harder to offshore or outsource than a generic due to the number of iterations required. Physical distance between production and design engineers also has an influence.
2) In order to handle the before mentioned complexity the production process and/or product can become more simplistic. For example, if a given function or task is offshored or outsourced which is technically or technologically complex, it may be necessary to lower the level of complexity in the production process or of the product itself.

Most case companies tried to counteract the added complexity with a more explicit development process. The interviewees meant that the processes needed to be codified in detail to ensure quality and facilitate communication. This lessens the chance of misunderstandings based on culture (organisational or national) as well as the impact of physical distance. For some companies, for example X4, they saw a need for the process to be more explicit but also felt cultural and physical distance meant the processes became more complex and harder to make explicit. X4 had a spiral product development process which meant many iterative changes to the product. However, cultural and physical distance to their production vendor in China meant that changes took several months to be seen, as shipment alone took 6 weeks. The design engineers in Denmark would decide product improvements based on the latest batch received from the vendor and give overall specifications. However, when the vendor was told to implement these processes their production engineers would have difficulty implementing them, and the ad hoc documentation from the design engineers in Denmark was often misinterpreted. An interviewee from X4 explained the need for more explicit processes, "*We know we have to be more detailed both out there and in the incoming area – for what they have to check for. And that is the hard lesson. […] You have to tell them in details [what to do]…. And that is not normal here [in Denmark]*." X4 was able to lessen the language and cultural barriers by stationing a design engineer with the vendor in China. However, as soon as he left and could no longer elaborate on the documentation, the vendor was again unable to comply. X4 changed their development process in an attempt to make the overall process easier to handle by gathering as many changes in one development run as possible. However, X4 kept having difficulties with quality, cultural and language barriers and transferring specifications. Their solution was to announce their outsourcing endeavour as failed and bring their production back to offshored locations in Europe (or back to facilities in Denmark) in an attempt to lessen the distance between design and production engineers by removing the physical, cultural and language barriers.

X1 also had a spiral product development process which meant many iterative changes to the product. However, they avoided the difficulties X2 had by codifying their processes and using expatriate engineers who acted as liaisons between engineers in China and Denmark. When this worked satisfactorily X1 offshored backwards in the development process, moving testing and then some parts of design abroad as well. Today the offshored location handles certain product lines from system level design to production. These product lines are the less technically complex lines as technology and educational level has meant X1 has had to simplify some of their processes to make them suitable for offshoring and to keep such changes to a minimum.

X2 had a generic product development process with stage gates after each function which meant less communication back and forth between design and production engineers. However, they found that most of their processes could not be made explicit as they were embedded in routines and the organisational culture. As a consequence, X2 bought the production sites from their outsourcing vendor and started to develop their organisation culture there. They transferred their processes through employee exchange programs, training programs, and site visits.

X3 also had a generic product development process. When offshoring, X3 would document the processes which they had not yet documented and update existing documentation before sending the function abroad. Knowledge about how a process was carried out which was embedded in routines and organisational culture had to be made explicit to move it. Unlike X4 which had offshored the entire production at once, X3 had only offshored parts of production for certain product lines. These were chosen because the products were mature and documentation changed less often. When this worked as expected, X3 would slowly move backwards in the development process and start to offshore production ramp-up and testing for modern products with new versions or smaller upgrades. X3's strategy was from the beginning to have some design engineers at the offshored factory to ensure documentation was understood, and make changes if needed. After reaching a common understanding, the expatriates would leave and the factory would be run by local engineers and managers.
X5 had first offshored production and thereafter outsourced a large part of it to save money. X5 also had a generic development process and had chosen to grow their site in India as knowledge and experience grew. Besides detailed documentation, X5 also used exchange programs extensively. In order to avoid cultural issues, X5 tried to hire only Indians whom they felt could work in a western business culture. They had also only moved standardized product lines to India so while design was needed it was minor changes carried out within clear specifications.
The following results can be drawn:

- X1 succeeded with offshoring and outsourcing due to awareness of the need for explicit knowledge of their spiral product development process and where this knowledge resided within the company. They outsourced to gain new competences and this enabled the creation of a more complex product. They avoided issues with communication and culture by using personified knowledge in the form of expatriates and exchange programs.
- X2 was unsuccessful with outsourcing of their generic product development process as they were not aware of what knowledge they had, and how this could be transferred.
- X3 was successful with offshoring because the product development process was made explicit before it was moved, and what knowledge could not be made explicit was shared through exchange programs and the use of expatriates.
- X4 was unsuccessful with outsourcing their spiral development process due to a lack of awareness of their own knowledge and how to transfer it. Using an expatriate engineer as a go-between reduced the added complexity of culture, language and time zone but didn't entirely remove it. An attempt to simplify the process by gathering changes into one large iteration did not work as this delayed the product further.
- X5 was successful with offshoring their generic development process thanks to clear specifications, intense knowledge sharing through documentation and exchange programs, and a serious attempt to transfer the same western organisational culture to all their locations.

5.3 Reasons for difficulties with implementing the control actions

Figure 6 shows the five unforeseen issues after the case companies had offshored or outsourced. These were culture, quality, physical distance, a lack of codified knowledge of the product development process, and a lack of consistency between practice and the already codified knowledge.
The five issues discovered during the empirical investigation are connected:
Codifying knowledge of processes
A very brief preparation phase meant the company was not clear until implementation was underway about how much of their product development process had been documented, and was updated, and what needed to be documented. This lead to quality issues and a greater impact of cultural differences, as there was no common documentation.
Physical distance
The lack of a thorough preparation phase meant that the physical distance came as a surprise. This involved both product shipment time, and the inevitable delay between product specification changes and implementation. This made a spiral product development process – and an iterative product development process used when the product was still under development - more demanding than a

generic development process due to more communication and interaction; an interaction which the codification issue made more acute.
Poor quality and a lack of codified knowledge were the most frequent difficulties. Quality issues were seen as a consequence of this lack of documentation. The lack of documentation was the case for companies who had been through only a very brief preparation phase. In these cases the knowledge needs for the given function or a part of a product under consideration for offshoring or outsourcing had not been investigated. This meant that it was only in the middle of moving the function that the need for documentation was discovered. At the same time, a lack of documentation in regard to processes was also revealed. The lack of consistency between practice and codified knowledge is also connected to this, as it wasn't discovered until the documentation was to be moved.
Culture became a large issue, not only due to a brief preparation phase wherein cultural differences were not debated, but also magnified through the lack of documentation which made it difficult to be certain communication and knowledge had been shared successfully. X1 felt the difference in individualism strongly, while X5 felt the difference in power distance (Hofstede, 1991). X4 experienced many delays due to the physical distance because they ran a spiral product development process which required much iteration.

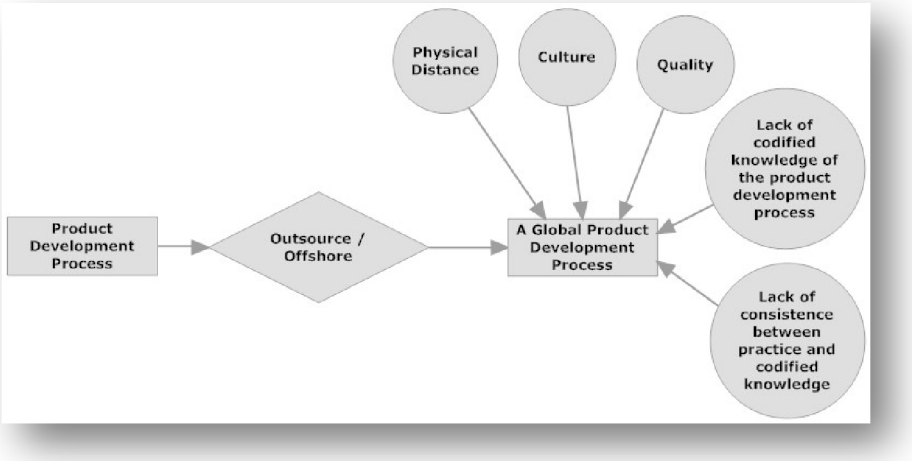

Figure 6. Unforeseen issues when offshoring and outsourcing

5.4 Possibilities to make organisational improvements

The following possibilities for improvement to the organisation while initialising the control actions on the product development process were discovered;

1) Processes can be redesigned for greater efficiency.

A control action of moving functions or a part of a product abroad to lessen the impact of increased complexity was documentation of processes. This documentation phase can be used to ensure documentation is created for all locations and all processes and not just what is being outsourced or offshored. Existing documentation can be updated and current work-arounds can be uncovered. Starting from 'a blank page' also enables new and better ways of doing things which could be implemented at the other sites.

2) The supply chain can be redesigned.

Outsourcing or offshoring can be seen in a long term strategic perspective for the overall outsourcing and offshoring of the product development process. At the same time, supply chain proximity can be considered with customers and tier 1 suppliers.
Most companies saw the impact on the product development process as unexpected and had difficulty handling it. Few of the case companies were able to see overall organizational improvement. Only X3 really saw this long term strategic perspective. They used the requirement for codification of their product development processes to also improve these processes – both production and development - for greater efficiency and consistency. The CEO of X3 explained the importance of having explicit

processes, *"[…] You are forced [to codify knowledge] […] you make a better description so you get better quality. […] you are forced to think if the processes you use here are going to be ok there. There are some processes that can't be written down [….] but most can. […] It's just not done often.*" One of the vice presidents gave the following example, "*….the engineers had a tolerance that no one could meet and we had our silent workarounds that worked, and all this "dirt" now comes to the surface. So there will be some changes to engineering.*" X3 felt they had become locked in routines and offshoring provided an opportunity to break out and redesign the production and development processes more efficiently. The CEO of X3 had also started to investigate the codification process to redesign the supply chain for greater efficiency. This meant consideration for the global footprint strategy for manufacturing that the company employed for offshoring facilities while keeping proximity to tier 1 suppliers and customers.

6. Evaluation

6.1 External validity of the results

The companies were in different sectors and in different stages of offshoring and outsourcing. The size of the companies also varied; in particular X4 had been a small company which had later been brought up by a large corporation. The challenges it faced when outsourcing may be more evident for small companies. Interviewees from the same company can have different perspectives depending on their own gain or loss in regard to power, position and knowledge as well as personal experience. However, by choosing participants from different positions this has been attempted to be addressed. The difference between choosing to offshore and outsource were beyond the scope of this paper. However, IP rights, organisational culture and control can influence knowledge sharing, transfer and generation in an outsourcing situation contrary to offshoring.

6.2 Use of the results

These results can lessen the risk of a failed move or investment. Less dramatically, it could save the company valuable time by lessening the chance of miscommunication and misunderstandings based on missing documentation or cultural difficulties. Greater insight into the company's development process through codification can provide a common frame of reference from which new ideas can be built and old ones improved and expanded. It leaves the option of improving efficiency and flow in the process itself, and lessens the chance of costly rework. Outsourcing and offshoring becomes a learning experience in greater internal understanding as much as a way to meet business targets.

7. Conclusions and further research

Interviews conducted in five companies showed the impact of outsourcing/offshoring functions or parts of a product on the product development process. The study showed that the impact can be both negative and positive. The key impact was the possibility of a more complex development process due to cross-cultural virtual communication and collaboration. The added complexity of communication, culture and physical distance, means a spiral development process is harder to offshore or outsource than a generic one, as it requires greater communication and interaction between the different development stages due to the iterative processes. However, this complexity can be lessened by making the process or product simpler and by codifying and documenting processes and tasks to provide a common frame of reference.

The case companies encountered several problems with implementing these control actions; for example culture, miscommunication, quality and transport time. This seemed to be caused by a brief preparation phase which meant the need for codification, documentation and simplification to counteract the added complexity was not conducted until the company had already moved the function or product part abroad. Furthermore, a thorough investigation of whether this was possible or desired ways to counteract this before mentioned complexity was left as a 'learning by doing' experience.

These results suggest that offshoring/outsourcing a certain part of a product is only possible if it involves discrete tasks, and when the company knows where the relevant knowledge resides and how

it can be shared. Doing so can even increase product complexity if the outsourcing is done to gain new competences. In the case of offshoring/outsourcing the development of a part of a product, product integration is vital. When offshoring/outsourcing a whole function, separation and codification seem to be the key issue for success. Partial functional offshoring/outsourcing due to cost reasons seems to lead to simpler products due to the before mentioned impact of added complexity. Here integrated processes become the key factor.
The implications for engineering education seem to be a focus on the impact offshoring/outsourcing has on the product development process, including the knowledge implications and culture. The study showed that further research is needed to understand what contributes towards a successful separation and later integration when a part of a product or a function is offshored or outsourced. Further studies are also needed to develop a framework to view development process models within a global context.

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