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DECISION MAKING PROCESSES FOR GLOBAL PRODUCT DEVELOPMENT – A CASE STUDY

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ABSTRACT

Global Product Development (GPD), outsourcing and offshoring of product development is a widespread phenomenon on today's global economy, and consequently most engineering manufacturing companies will have to make decisions regarding how to organise their product development activities globally. This paper investigates decision making in the GPD context, partly by summarizing existing literatures and studies in the field, and partly through a case study of decision making processes in a global engineering company. Through interviews a range of GPD decisions were mapped and analysed in order to investigate how decisions are made and which information decisions are based on. The study found that decision making is not always structured, and that prioritised decision making is more dominant than planned decision making. The findings set the stage for further analysis of decision making in GPD, and for development of support tools decision support tools for manager, which are based on empirical evidence and experience.

INTRODUCTION

Engineering companies rely more and more on Global Product Development (GPD) in order to stay competitive and innovative in today's global market (Tripathy & Eppinger 2011). This means that most organisations at some point must make decisions regarding which development activities to carry out in which part of the world, and consequently outsourcing and offshoring decisions are being made. A closer look into research and the understanding of decision making for GPD reveals that the decisions are often made on an ad-hoc, or "learning-by-doing" basis, and therefore the decisions often not lead to the desired results (Hansen & Ahmed-Kristensen 2012), and dealing with incomplete or inaccurate information for decision making imposes challenges for the methods and processes used (Shishank & Dekkers 2013). This points towards a need for a better understanding of how decisions for GPD are made, which methods can support the decision making process, and which information is needed for the decision makers to make good decisions (Shishank & Dekkers 2013). The explorative study in this paper presents a case study of decisions related to managing outsourcing and offshoring of product development activities and projects from the perspective of strategic management. Furthermore possibilities for more detailed research on the topic are identified. The paper proceeds with the following structure: First, a general background of the research field and the relevant

theories for global product development and outsourcing/ offshoring decisions are presented. The research questions and conceptual model for the study are elaborated, followed by an outline of the research methodology and a presentation of the data collection and analysis. The main results are presented, together with a discussion and conclusion.

THEORETICAL BACKGROUND

This section outlines the current trends within global product development from an engineering management view, and sums up the decision making literature related to outsourcing and offshoring of engineering and product development tasks. The review of the existing research and theories in the field establish an understanding of the extent that the results from the case study support or contradict existing research. First a general introduction to the globalisation of product development is given. This is followed by a review of decision making related to GPD, and the factors that affect GPD decisions. The section concludes with an overview of current decision methods applied in GPD and points towards the research gap.

The globalisation of product development

Whereas outsourcing and offshoring of manufacturing is a fairly well established field, and its practice has been widespread among engineering companies over the last three decades, the outsourcing and offshoring of R&D is a relatively new activity, and hence the research in the field is still nascent with relatively limited academic literature (Bardhan 2006). Another characteristic of the phenomenon of outsourcing and offshoring R&D is that the study lies in the junction of many fields, including business studies, engineering design studies and operational management studies (Bardhan 2006).

The current highly competitive global environment has been referred to as an outsourcing economy, characterised by leveraging of external resources, skills, knowledge, capabilities and competencies, where companies of all sizes in nearly all industries capitalize on external sources of knowledge and capabilities (Hätönen & Eriksson 2009). Such a rapid spread of outsourcing and offshoring means that firms face new, complex issues of organisational structure (Bardhan 2006) and opening new global R&D centres will most likely affect all parts of the organisation (Khurana 2006). A trend for GPD observed in recent years is that offshoring and outsourcing has moved up through the value chain, from being mainly focused on production, to include all steps of the engineering value chain (Hansen & Ahmed-Kristensen 2012). Since the 1990s, R&D centres have gradually moved to emerging markets in Southeast Asia, India, and China (Zedtwitz et al. 2004). While outsourcing and offshoring was earlier focused mainly on manufacturing tasks (the outsourcing wave of production to low cost countries in Asia), it nowadays also includes R&D and overall innovation activities (Bardhan 2006). More complex and higher value adding activities are increasingly being offshored, requiring access to expertise and highly skilled workers in the offshoring locations (Lewin et al. 2009). Zedwitz et al (2004) found that the first generation of international R&D organisations are characterised by R&D duplication, meaning that the home R&D set-up is duplicated in the new location, while more advanced R&D organisations assign different competencies to each R&D unit (Zedtwitz et al. 2004).

Survey results from an Outsourcing Research Network (ORN) study from 2004-2006 concluded that new product development (NPD -including product design, engineering services, and R&D) was the second most frequently offshored business function after IT (Manning et al. 2008). Although most global companies still conduct R&D in their home country, trends go toward having smaller R&D facilities in strategic locations rather than all in one place (Khurana 2006). Although this trend has been predominant some time, the research concerning offshoring of higher skilled development processes is still in its early adopter phase (Manning et al. 2008).

Drivers for GPD

In order to understand the outsourcing and offshoring decisions, it is relevant to understand what the main drivers are for outsourcing development tasks. This has been fairly well researched in the past across different industries, and the dominant driver has been cost savings in various forms (Eppinger & Chitkara 2006; Makumbe et al. 2009; Hansen & Ahmed-Kristensen 2011). However, more recently several studies have concluded that the labour arbitrage opportunities may become less important, and that strategic global R&D also should take other factors into account in complement to cost savings, i.e. access to technology, markets and talent (Khurana 2006). Correspondingly (Manning et al. 2008) came to the conclusions that for a growing number of companies, reducing labour costs is no longer the only strategic driver behind offshoring decisions.

Drivers identified in literature were compared to the drivers mentioned by Danish engineering companies in a 2011 survey from Statistics Denmark (Søndergaard & Ahmed-Kristensen 2014) where the companies listed their main motivations for outsourcing. The results are in compliance with the findings from literature, and labour cost reductions were considered the most important motivation by Danish companies who outsource; with 85% stating that this is a very important or important motivation. Other cost reductions than labour cost are also an important motivation, with 77% marking this as important or very important. This supports the trend found in literature, considering cost reductions to be the central motivational factor. Access to new markets and reduction of delivery times also ranks among the more important drivers (Søndergaard & Ahmed-Kristensen 2014).

Challenges in GPD

One of the most frequently mentioned challenges in relation to GPD is cultural differences (Hansen & Ahmed-Kristensen 2011; Makumbe et al. 2009; Lewin & Peeters 2006). As GPD has a geographically distributed nature, communication often relies heavily on digital channels rather than face-to-face communication, and this can increase the cultural difficulties experienced among distributed development teams (Lewin & Peeters 2006). Challenges regarding knowledge transfer and documentation are also found to be difficult to address as GPD sets new requirements for the way an organisation deals with knowledge management. This is an example of a challenge where some of the companies studied actually experienced increased development times, increased cost etc. This indicates that the capabilities of overcoming these challenges should be included when making a decision assessment. A general conclusion is that many of the challenges identified in literature are related to the fact that GPD is geographically dispersed across different cultures.

In an earlier study, challenges from literature were compared with experiences in Danish companies based on survey data from Statistics Denmark (Søndergaard & Ahmed-Kristensen 2014) where companies ranked the importance of barriers for carrying out

international sourcing. Here it was found that while cultural challenges receive most focus in literature, the survey results showed that the most important barrier is the proximity to existing clients. In addition, 15% said that overall concerns were exceeding the expected benefits. Linguistic or cultural barriers were only considered very important by roughly one out of ten. This indicates that it is not seen much as a barrier by the companies when considering GPD, but it becomes a challenge once the companies have globalised their development.

DECISION MAKING AND GPD

Having established an understanding of the background, drivers and challenges for GPD, it is important to know the current research in strategic decision making related to GPD. Decision making has been thoroughly researched over a longer period (i.e. (Eisenhardt 1997; Ullman 2001; Dekkers 2011; Kremic et al. 2006; Hafeez et al. 2007)), as well as the link between strategic decisions and success, but less emphasis has been on researching the role and importance of implementation (Hickson et al. 2003). A framework for outsourcing decisions was proposed by (Kremic et al. 2006), including parameters such as benefits, risks and influencing factors in the evaluation of the outsourcing decision. Others have proposed similar frameworks or processes for decision making from different perspectives; an overview of some of the key frameworks and references is shown in Table 1.

Table 1: Research within decision making in GPD

Research	Focus	Tools	Decision type	Domain
(Kremic et al. 2006)	Outsourcing	Outsourcing decision framework	Strategic	Supply Chain Management
(Barragan et al. 2003)	Strategic sourcing	Four step framework for strategic sourcing	Strategic	Supply Chain Management
(Christodoulou et al. 2007)	Outsourcing/ Offshoring	Four step framework for planning global manufacturing	Strategic & operational	Manufacturing / Engineering
(Eppinger & Chitkara 2006)	Outsourcing/ Offshoring	Key success factors for GPD	Strategic & operational	Product development
(Tripathy & Eppinger 2011)	Outsourcing/ offshoring	Sourcing location matrix	Strategic	Product development
(Dekkers 2011)	Outsourcing	Model for continuous decision making for outsourcing	Strategic	Operations / production management
(Hansen & Ahmed-Kristensen 2012)	Outsourcing/ Offshoring	Framework (GDM)	Strategic	Product development
(Khurana 2006)	Strategic planning	Four step planning model	Strategic	Management
(Zedtwitz et al. 2004)	Research & development	Six Dilemmas in global R&D	Strategic	Management

What to outsource/offshore?

The key strategic decision for the company is the question of which activities should be moved out to other locations. As described earlier, there are a number of different drivers for GPD, and depending on the motivation, the tasks considered for outsourcing or offshoring might be very different. However, some general considerations can be identified from previous research. The concept of core competencies (also known as the competency based view) is often referred to as a way of deciding which activities are suitable for outsourcing or offshoring (i.e. (Dekkers 2000; Hätönen & Eriksson 2009) and the theory of the competence based competition has been explored both in academia and among practitioners (Hafeez et al. 2002). In general, it is agreed that corporate strategy should be built upon the core competencies of the firm (Dekkers 2000). In line with the core competencies approach is the notion of routine tasks vs. creative or complex tasks. Routine tasks are considered more suitable for outsourcing, whereas more complex R&D tasks call for intra-organizational offshoring, hence keeping control over them (Bardhan 2006). Other studies are aligned with this splitting of tasks into routine and creative tasks, and suggest that while creative tasks should be kept close to the core organization, routine tasks (i.e. detailed engineering) can more easily be moved to distinct R&D centres (Khurana 2006). The new outsourced R&D centres typically do routine tasks, and support the main R&D in the headquarters of the company. However, they can evolve over time and become more autonomous, taking up more innovative tasks (Khurana 2006). A general term for these kinds of decisions, adapted by research in management as well as business and engineering research, is the term "make-or-buy" decision. Numerous studies have looked into the make-or-buy decisions and several different frameworks for making and supporting these types of decisions have been developed. For example (Cánez et al. 2000) have proposed a framework and process for make-or-buy decisions, which includes four phases in the decision process: Preparation, data collection, data analysis and feedback (Cánez et al. 2000). The sourcing-location matrix from (Tripathy & Eppinger 2011) also gives an indication of when to make and when to buy, with coordination requirements and strategic value as the deciding parameters for when to make or buy.

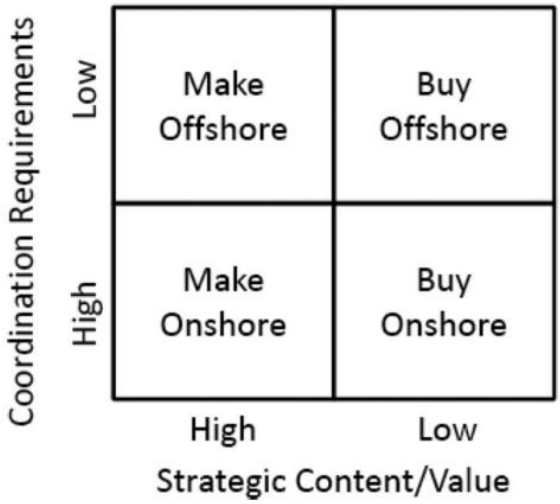

Figure 1: Sourcing-location matrix. From (Tripathy & Eppinger 2011)

A pure "make" strategy is high-cost, but enables the firm to be highly responsive to changing needs, whereas a combined make and buy strategy may lead to lower costs, gained knowledge, shorter time-to-market and enhanced innovation (Cruz-Cázares et al. 2013). Most GPD companies will have a combination of make and buy strategies in their global production.

Where to outsource/offshore?

Another important strategic decision is the decision of where to place the outsourced and/or offshored development activities (Hätönen 2009). The far east (especially China) as well as southeast Asia and eastern Europe have become "hot-spots" for outsourcing and offshoring during the last 20 years (Eppinger & Chitkara 2006). The location choice can be based on many different parameters, depending on the company, the previous experience and the existing activities or physical footprint of the company. Commonly, some of the key parameters to consider are: wage advantages, country risk, country experience, infrastructure, access to skilled workers as well as government and political factors (Demirbag & Glaister 2010; MacCarthy & Atthirawong 2003). Methods for making the location choice are discussed later in this section.

How to outsource and offshore?

Once the questions of what to outsource or offshore have been answered, and the location decision has been made (strategic decisions), the next step is to decide how to set up and operate the GPD organisation. This requires a management effort. Previous studies have found that one of the reasons that these decisions often lead to challenges, is the lack of change management efforts and project management efforts (Hansen & Ahmed-Kristensen 2012).

FACTORS AFFECTING GPD DECISIONS

Having established an understanding of the typical GPD decisions, it also important to understand which factors affect these GPD decisions. These factors can be categorised into two main groups: external and internal factors (Cruz-Cázares et al. 2013). Lewin et. al (2009) suggested three key factors that affect the offshoring dynamics at different levels**:** Environmental factors (macro-level), managerial intentionality (micro/project level) and organisational path dependency and learning (meso-level) (Lewin et al. 2009). Another study concerning the factors affecting location decisions by (MacCarthy & Atthirawong 2003), lists five major factors and ten sub-factors influencing the location decisions, based on a Delphi study. These factors both include cost driven and other factors like telecommunications and availability of labour force. Where cost has traditionally been the most important factors, more recently the global race for talent has been mentioned as trend affecting the globalisation (rather than the race for cost savings) (Manning et al. 2008; Lewin et al. 2009).

Historically, most companies have started with an outsourced relationship in order to test the model before making longer commitments (Khurana 2006), and a common observation from previous case studies is that a learning-by-doing process, where expertise is progressively developed over time is prevalent (Lewin & Peeters 2006). This is also the case in Danish firms, where empirical studies show that "offshore sourcing in low-cost countries is best described as a learning-by-doing process in which the offshore outsourcing of a corporation goes through a sequence of stages towards sourcing for innovation"

(Maskell et al. 2007). This indicates that while there are many factors influencing the global product development decisions, learning-by-doing is a major influence that cannot be ignored.

Another factor that has received much attention is hidden costs. In most cases, it is impossible to calculate all costs of the offshoring or outsourcing decisions, and some hidden costs will reveal themselves after the decision has been made. "The sheer change in the configuration of activities from a typical co-located R&D organization to a globally disaggregated and dispersed R&D network in itself entails some ''hidden costs'"" (Andersson & Pedersen 2010). A study of hidden costs of offshoring (Larsen et al. 2012) also concluded, that more complex offshoring tasks are likely to result in higher cost estimation errors due to hidden costs, and that these cost estimation errors can be reduced by a strong orientation towards organisational design when making the offshoring decisions. Another characteristic of GPD is the increased use of and dependence on virtual collaboration in different locations. Information and communications technology (ICT) tools are essential for mutual understanding of development tasks and achievements if two units are not co-located. How virtual global teams can be used foster successful global product launches has also been a central point of investigation for research, i.e. (Harvey & Griffith 2007) and (Zedtwitz et al. 2004), where the latter pointed out, that even though ICT is necessary for global knowledge management, the tools are not yet sufficient, as learning between individuals requires trust, which is not easily established through ICT. Therefore GPD decisions should also consider whether the organisation is equipped to facilitate the necessary collaboration through ITC tools.

CURRENT DECISION MAKING METHODS

Decision making is applied in many fields (i.e. supply chain management, risk management, operations management and product development) but has until now received limited amount of attention in connection to outsourcing and GPD decisions (i.e. (Dekkers 2000; Hafeez et al. 2007; Kumar et al. 2009). What characterises all of these is that they focus on only one aspect of decision making, i.e. location decisions or make-or-buy decisions. The analytic Hierarchy Process (AHP) is an example of suggested decision making methodology to evaluate the location options and decide for the optimal location, and especially in the operations management literature, there are several examples of using the (AHP) for assessing and evaluating location decisions (Lin et al. 2007; Vaidya & Kumar 2006; Badri 1999). Other methods include scenario planning, risk breakdown structure and case based reasoning. An overview of the most common decision making methods and their application, advantages and limitations is shown in Table 2.

Since different methods are useful for different GPD decision types, a decision making framework should facilitate assessment of several different parameters such as core competencies as well as capabilities to overcome cultural challenges, capabilities for documentation and communication and the capability to deliver the required quality on time (Hansen & Ahmed-Kristensen 2011).

Table 2: Decision making methods and GPD. From (Søndergaard & Ahmed-Kristensen 2014)

Reference	Method	Application examples	Advantages	Limitations
(Saaty 1990)	AHP	• Location selection • Key capabilities	-Systematic - Useful for well-defined problems and options	Difficult to include "soft data"
(Drew 2006)	Scenario planning	• Strategic choice • Supplier selection	-Encourages learning - A means of testing assumptions -Supports sophisticated treatments and analysis of a company and its environment	- Occasionally too little focus on the decision context. -Relies on soft data. - Time and resource consuming.
(Hillson 2003)	Risk Breakdown Structure (RBS)	• Risk assessment	- Lessons learned for future projects - Comparison of projects / tenders - Risk assessment - Risk reporting	- Requires risks to be well defined - Takes time to build experiences
(Brans et al. 1986)	PROMETHEE	• Selection and ranking of projects • Location selection	- Supports more dimensions than AHP alone	- Needs to be combined with AHP
(Choy & Lee 2002)	Case based reasoning (CBR)	• Supplier selection	- Enables reuse of engineering knowledge	- Limitations when addressing a wide range of decisions

Planned vs. prioritised decisions

Hickson et. al. (2003) distinguishes between planned and prioritised decision making. If management acts experience based, this leads to the planned option. If management on the other hand lacks experience and know-how, the prioritised option might be more relevant and also preferable if it is a novel decision (Hickson et al. 2003). A mix of both options has the best chance of full success, and Hickson argues that this is because planned option gives stability, while prioritised leaves room for new learnings to be included in the process. The concept of planned vs. priorities decisions will be used to evaluate the decisions from the case.

The gap: Managerial decision support tools

Previous research in GPD has focused on key success factors for GPD, but has also pointed towards a lack of practical support tools that mangers can use when making the GPD decisions (Eppinger & Chitkara 2006). Several researches have stated that information in the early stages of product development (design and engineering) is almost always incomplete and inaccurate. Through the iterations, detailed data becomes gradually more available. (Shishank & Dekkers 2013). This makes it difficult to use many of the decision methods mentioned in the previous section, as most of them assume that all relevant information is readily available when making the decision.

In a field study, (Chiesa 2000) concluded that success of global projects depends on whether the R&D structure is supported by appropriate managerial and organizational tools. Earlier research in GPD has focused on the key success factors for GPD but also pointed towards a lack of practical support tools for managers (Eppinger & Chitkara 2006). The need for decision support tools, and further studies focusing on GPD decisions has also

been highlighted by (Hansen & Ahmed-Kristensen 2012). Cost reductions have traditionally been seen as the main rationale for GPD, but more recently it has been suggested that companies should *not* only focus on cost, but have a more integral decision making based on the appropriate method and tools (Dekkers 2011). As described earlier, a number of different methods for supporting the different kinds of decisions (strategic as well as operational decisions) have been proposed. However, we suggest that the decision making process is more iterative, and that decision support should therefore facilitate iterations, and build on previous experience as well as facilitate continuous decision making. Therefore, in order to be able to develop such decision support tools, a more deep understanding of the decision types, and decision processes based on empirical insights is needed in order to develop more generic and holistic decision support tools. The deeper understanding of decision processes and methods is what the case study presented here addresses.

RESEARCH QUESTION

Based on the above described background and recent trends in GPD and the existing knowledge about decision making in a GPD context, the aim of this study is to contribute with an understanding of how GPD decisions have been made, and based on the drivers and methods to classify what the outcome of the decisions has been. Therefore, the overall research questions addressed here is:

RQ1: How are decisions regarding outsourcing or offshoring of development tasks currently undertaken, and which information is needed to support managerial decisions?

Based on the overall research question, three sub-questions to be answered in this study have been formulated:

1. *What was the main driver for outsourcing/offshoring of PD tasks in the case?*
2. *Which methods have been applied (if any) to make specific decisions in the case?*

These questions serve as a starting point for analysing the mapped decisions from the case study, and will either be falsified or verified through the case study.

RESEARCH METHODOLOGY

Having established the background and the propositions and research questions, this section describes the chosen research method as well as the data collection approach. Specifically the case study approach and the descriptive and exploratory character of the research demands some explanatory description. The research design presented here is based on the Design Research Methodology (DRM), developed by (Blessing & Chakrabarti 2009) (Figure 2).

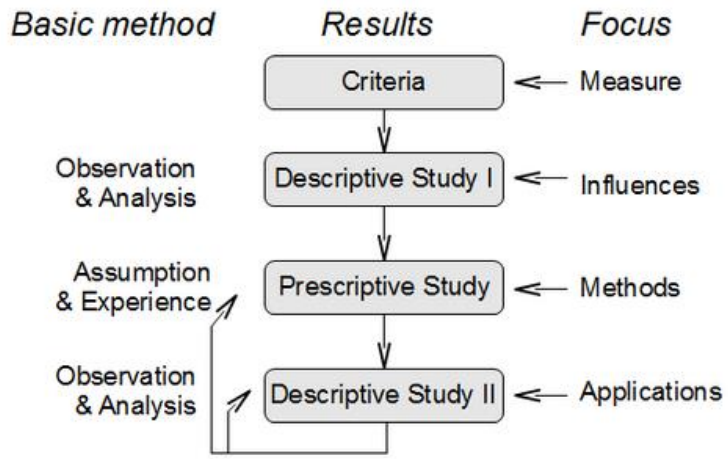

Figure 2: DRM framework. From (Blessing & Chakrabarti 2009)

The DRM comprises of prescriptive phases (observation and analysis of the studied phenomenon) as well as a prescriptive phase (where the findings from the descriptive phase are transformed into new methods or frameworks). The work presented in this paper, is the partial result from the descriptive study 1, focusing on observation and analysis of decisions in an industrial case setting.

Case study

Due to the explorative nature of the study, this research applies a single case-study approach, which allows us to achieve an in-depth understanding of the research topic (the decisions) (Yin 2009). The research draws on qualitative data, collected through in-depth interviews with decision makers at different management levels in the case company. Referring to (Yin 2009), the research builds on the embedded single-case design, where the embedded units of analysis are the single decisions made in the context of a single case. The case company was selected based on two criteria; a) the company has product development and engineering department, and b) the company has several global development locations.

Interviews

Thirteen interviews were conducted in the case company with employees at different levels and at three development locations (one in Denmark and two in Asia). All interviewees had been involved in one or several GPD projects in the past five years. The interviews were semi-structured interviews of one hour duration, and the interviews followed a pre-defined interview protocol with themes based on literature. The themes were: Decision making (who, what and how), decision implementation (how), decision understanding, decision outcomes and lessons learned as well as suggestions for improving future decision making. The structure of the interviews was adapted to the individual interviewee, depending on their level and involvement in decision making. All interviews were transcribed in the *Atlas.ti* software for data coding and analysis.

THE CASE

This section presents a brief description of the case company, the global development set-up in which the company operates today, and the GPD decisions that have been made in the case company. The case company is a manufacturer of medical aid equipment with a Danish based headquarter, and with worldwide sales and R&D activities. Development is focused in development centres in Denmark, Asia, the UK and the US. The case company uses a standardised product development process (PDP) which is implemented in all development locations. The Danish headquarters of the case company hosts the executive management, as well as marketing divisions. Most other functions such as product development, quality assurance, process design are represented both in the headquarters and the foreign development sites, whereas manufacturing is mainly based in the development sites, as the company has no production in Denmark.

Decision makers

Decision makers in the case company include both the executive management team (located in the Danish headquarters) and local project managers in the development sites. Strategic decisions are primarily made by executive management in Denmark, whereas more operational decisions are often made by the local project managers in the development sites (in close cooperation with the headquarters).

DATA ANALYSIS

All transcribed interviews were coded and analysed according to a pre-defined coding scheme. The coding scheme was developed based on a literature review, which identified overall themes, including decision motivation, decision type, decision input, decision methods and decision results. Based on these themes, a set of sub-codes was developed, with several codes for each theme. The coding scheme was developed over two rounds: The first round was a theory driven, top-down approach, where the categories and codes were derived from literature. The second round applied a more data driven, bottom-up approach, where additional codes were added when coding the interview transcriptions and new codes or categories emerged from the data. This was done in order to avoid data confinement. An overview of the overall coding themes is shown in Table 3.

Table 3: Coding scheme categories

Category	Definition	Codes (examples)
Type of GPD	Whether the project included outsourcing, offshoring or both	• Outsourcing • Offshoring • Outsourcing & offshoring
Motivation	What the main motivation was for the specific decision	• Cost reductions • Closer to production • Scalable resources • Access to new markets
Input	Which inputs lead to making the specific decision	• Market information • Business case • Requirements • Customer feedback

Assessment	Which assessments were made before making the specific decision	• Resource assessment • Cost considerations • Business case • Resource assessment • No formal assessment
Method	Which method was used for making the decision (if any)	• Ad-hoc decision making • Vendor selection process • Design review • Feasibility study • Resource planning
Decision type	Whether the decision was strategic or operational	• Strategic decision • Operational decision
Decision classification	Specification of the decision	• Offshoring decision • Outsourcing decision • Location decision • Product design decision • Process design decision • Market/commercial decision
Implementation	How the specific decision was implemented	• Create distributed team • Employee training • Process redesign
Results	What were the main results of the decisions	• Successful decision • Some challenges • Decision failed

Following the iterative development of the coding scheme, all interviews were coded in detail; all identified decisions were listed in a table, and for each single decision category data was identified and listed. The units of analysis are the single decisions, which were compared across all projects and interviews.

RESULTS

Data analysis was carried out across 32 different decisions, which were all of the decisions that were identified across the interviews. Each single decision was mapped out, with regards to: 1) The type of GPD (outsourcing or offshoring); 2) The driver/motivation for the decision; 3) The inputs and assessments made for the decisions (if these were identifiable from the interviews); 4) The methods applied for making the decisions (if any); 5) The decision itself; 6) the type of decision; 7) The implementation of the decision, and; 8) The identified effects of the decision (positive or negative effects). An example of a single decision mapped is illustrated in (Figure 3).

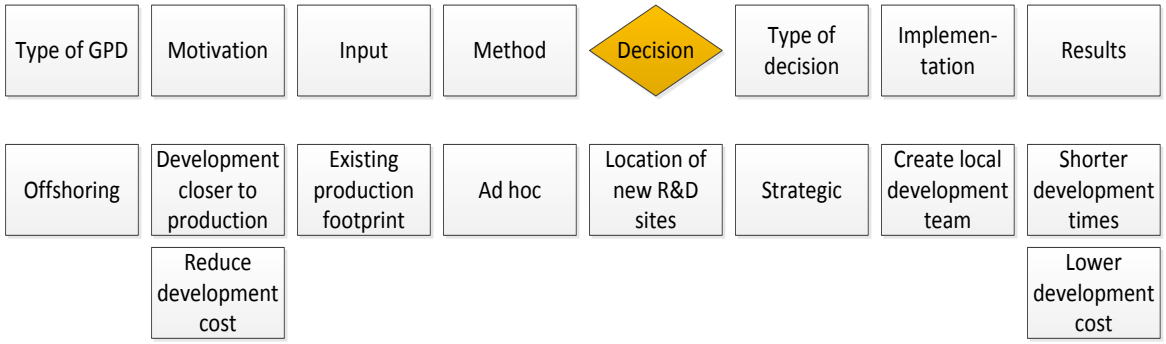

Figure 3: Example of single decision analysis

In the decision example taken from the transcripts, illustrated in Figure 3, the decision was a strategic decision regarding where to locate new R&D sites. The motivation for this decision was to move the development closer to production, and to reduce the development costs for new products. The input for the decision was the existing production footprint 8 the company already had production sites in Asia) and there was no structured decision making process identified, the decision was made based on unstructured discussions in the management team. After the decision to establish R&D in Asia was made, it was implemented by creating local development teams, with functions similar to the development functions in the headquarters. The decision resulted in shorter development times for new products (as part of the development was taking place closer to the production, and they achieved some synergy between development and production teams) and the overall development costs were lowered significantly. The decision is categorised as a successful decision, since the results met the goals set (motivation).

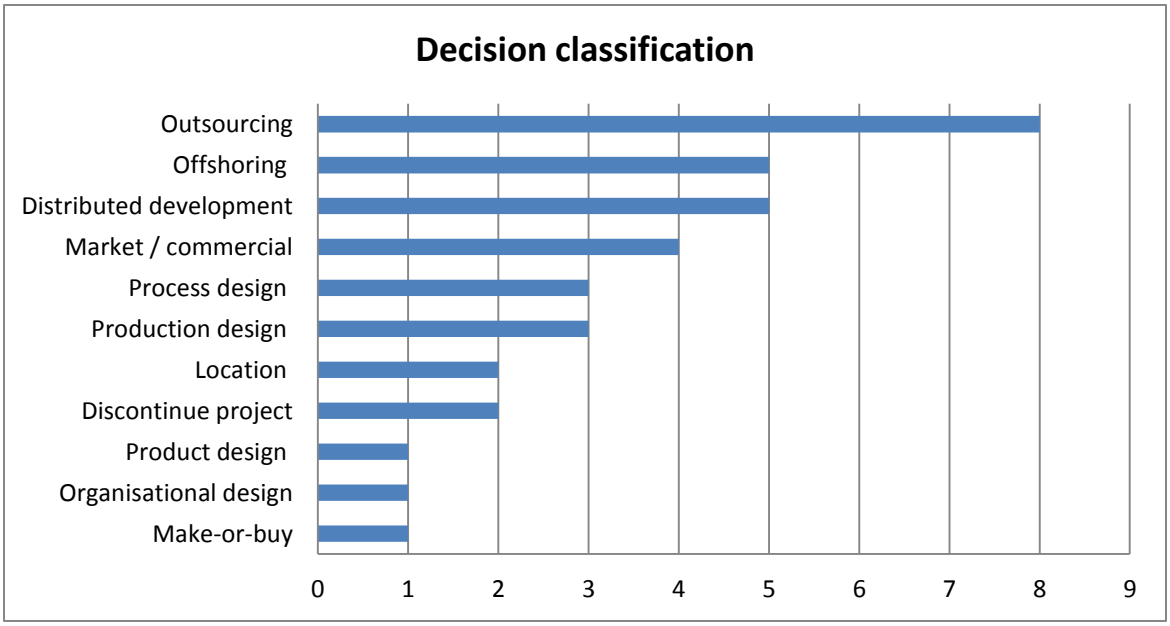

Figure 4: Decision classification

Decision classification

When looking across all decisions, the majority of the decisions where classified as outsourcing or offshoring decisions (Figure 4). These decisions are concerned with either

moving development tasks to an internal development center (offshoring) or to an external supplier (outsourcing). Distributed development (setting up development activities across the sites) and commercial decisions were also mentioned in several interviews.

Decision types

Out of the 32 mapped decisions, 24 were strategic and 8 were operational (Figure 5). Examples of strategic decisions include: Offshoring decisions, outsourcing decisions, location decisions, distributed development decisions, commercial/market decisions and make-or-buy decisions. Examples of operational decisions include: Decision regarding local suppliers of components, decisions regarding the product design, the process design and the production design. Strategic decisions were made by the executive management team in the headquarters, while operational decisions were made both by executive management, and local project managers in the development sites.

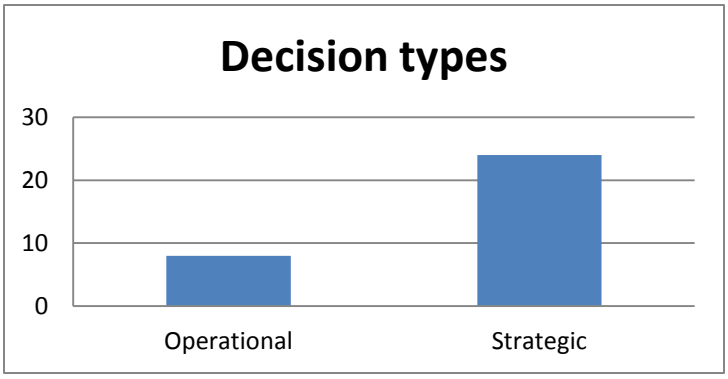

Figure 5: Decision types

Motivations

In the studied case, cost reductions played an important role in most of the decisions, but it was not the sole motivator, and often there were other central motivations, i.e. to have the development tasks closer to the production process and closer to production knowledge. In order to understand which drivers were behind which decisions, the motivations and decisions were mapped against each other. When the motivation is to gain new competencies, the decision is to outsource (in this case because the company outsourced development tasks with which they had no previous experience or competencies).

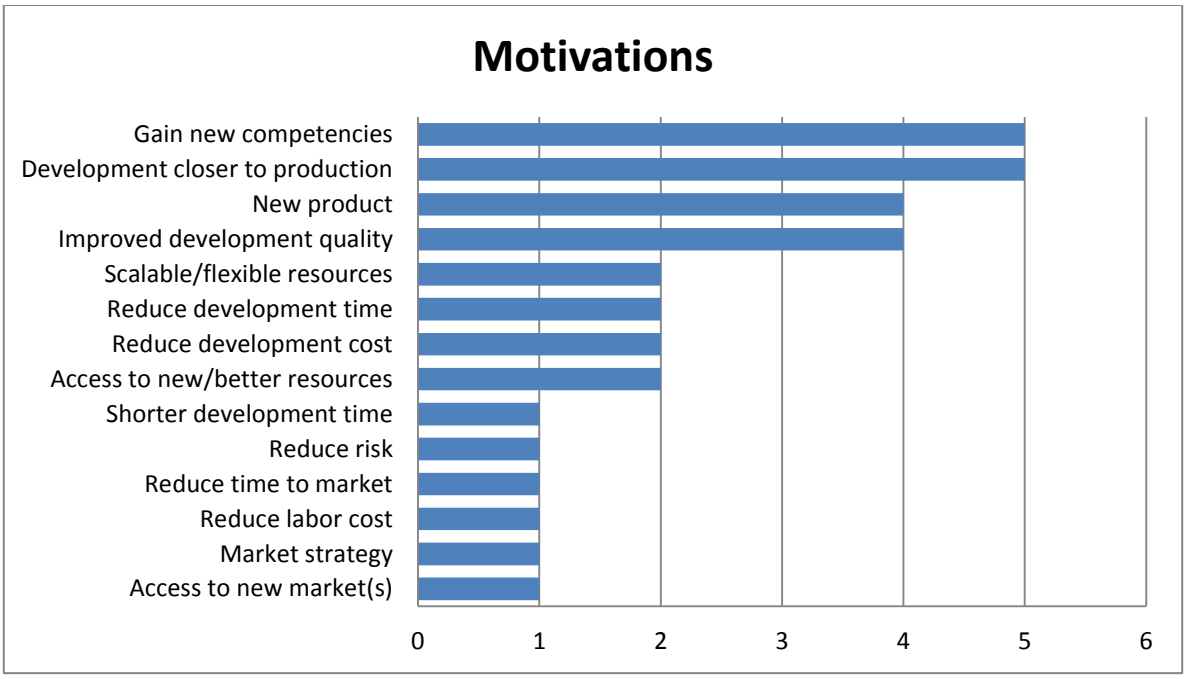

Figure 6: Motivations

Location decisions

Location decisions were made in two of the analysed decisions. The location decisions were in this case based on development closer to production and risk reduction. The location decisions were based on existing production locations (existing footprint) and both the new Asian development centres were placed together with already existing production facilities in China and Malaysia. Therefore there was no structured location-decision methods used for the location-decisions in the case. In practice this is often the case in companies who have already established production or other presence in locations abroad.

Decisions and methods

Analysis across the mapped decisions revealed that the majority of decisions (17) were made in a rather unstructured manner, and the process was difficult to map retrospectively (ad hoc decision making). The analysis across decisions shows that most decision processes are not formalised, and often the decisions have been made on a base of informal discussions in the executive leadership team. The types of decisions (decision classifications) were compared to the specific method used for each decision type. This revealed that most decisions were made in an ad-hoc manner across almost all the different decision types, and hence it is difficult to identify which information feeds into these informal decisions. However there are some indications of what information is needed for which decisions. For decisions regarding distributed development (setting up a global team), resource planning and risk assessments were used at input information for the decisions. For outsourcing decisions a vendor selection method was typically applied, as well as business cases and feasibility studies. For market decisions, a business case and design review was applied. For decisions regarding the product design, design review was used as the method, and for decisions regarding the production design, business cases and resource planning were used.

Table 4: Decisions and methods used

	Method						
Decision classification	**Ad-hoc decision**	**Business case**	**Design review**	**Feasibility study**	**Resource planning**	**Risk assessment**	**Vendor selection**
Discontinue project	2						
Distributed development	3				1	1	
Location	2						
Make-or-buy	1						
Market / commercial		1	2				
Offshoring	5						
Organisational design	1						
Outsourcing	2	1		1			4
Process design	1			1			
Product design			1				
Production design		1			1		

A mapping of decision types (strategic and operational) against the method applied correspondingly shows that especially many of the strategic decisions were made without a structured method. An example is the location decision, or the decision to start up a new development team in order to develop a new product line. Other examples show that i.e. business cases were used for making decisions (i.e. decision to outsource component production to a 3rd party vendor). The findings indicate that in many of the analysed decisions, these were made based on intuition and informal discussions in the management team rather than in a highly structured way with formal assessments and methods. The fact that most of the decisions were considered successful in the case company, indicates that a formal and structured decision making process is not considered necessary in this case.

Table 5: Decision types and methods

	Method						
Decision type	**Ad-hoc decision**	**Business case**	**Design review**	**Feasibility study**	**Resource planning**	**Risk assessment**	**Vendor selection**
Operational decision	1	1	1	1	1		2
Strategic decision	16	2	1	1	1	1	2

Referring to the notion of planned vs. prioritised decisions (Hickson et al. 2003), the case study revealed that the company has made mostly prioritised decisions, where management has had limited experience and know how, and has made and adjusted decisions along the way. However, there is also evidence of more prioritised decisions, typically in decision examples where the management had some sort of experience or know-how about the decision to be made. This indicates that decision support tools which are based on experience (from i.e. earlier experiences of other companies) can support management in

making more planned and less prioritised decisions, and hence lowering the need for "learning-by- doing" approaches.

DISCUSSION/CONCLUSION

An in-depth case study was conducted in a global engineering company in order to investigate how decisions regarding outsourcing and offshoring of product development tasks were made, and which information was used to support these decisions. The analysed decisions were both strategic decisions and operational decisions with a clear predominance of the former. First, the motivations (or drivers) for the decisions were analysed, and we found that in contrast to the common conception in literature, where cost is the dominant driver identified, that the case company had other motivations such as: moving development closer to production, gaining new competencies, and reducing the risk of developing a new, innovative product (which they would not have been able to do with their old setup with R&D only in the Danish headquarters).This can explain why the case-company has been successful in their decisions, as cost was not the only motivational factor. GPD in the case has led to lower development cost, reduced development time and new competencies in the global development centres.

It was investigated which methods had been applied in the different decisions, and found that for the majority of decisions it was difficult to identify any specific methods, and that most decisions were made in a rather informal manner. Different assessments were mapped for different decisions, but a structured method (i.e. like AHP for location decisions or for vendor selection) was not identified. This indicates that the decision process (at least in this case) is far more dynamic and iterative, and based on more informal assessments, meetings and processes than the theory often suggests. Across all mapped decisions, the majority can be classified as prioritised rather than planned decisions, or a mix of both (Hickson et al. 2003).

Implications

Decision support tools should be for top managers/executive management (those making the strategic decisions,) and should provide support for making different types of decisions, and provide them with means of assessing the required information, in order to make more planned decisions and less prioritised decisions. Since the decisions are highly case and context dependent, and consequently will vary across companies and industries, a decision support tool should facilitate the process rather than try to provide the answers (i.e. based on the type of decision and the drivers, the tool should suggest which steps and assessment are appropriate, based on empirical studies).

Limitations

This case study presents findings from a single case, and consequently the findings are very specific for the case company. Only one industry and product type is represented here (medical products), and therefore the case is not considered as being representative in general for Danish engineering companies. However, the study reveals interesting results to be investigated in further cases for comparison and generalisability. This should be the topic for further studies of decision making in GPD.

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