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DEVELOPING A SUPPORT TOOL FOR GLOBAL PRODUCT DEVELOPMENT DECISIONS

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1. Introduction

Global Product Development (GPD) has become a pathway towards competitive advantage for an increasing number of engineering and manufacturing firms [Eppinger and Chitkara 2006], [Hätönen and Eriksson 2009], [Lewin et al. 2009]. For various reasons, including access to new markets and resources, proximity to existing manufacturing locations, cost reductions etc. product development processes are becoming more and more distributed globally. The transition from traditional, co-located product development to GPD adds complexity to both product development, management and the overall operations of the engineering firm. Decisions about how and where to place GPD must be made both on the strategic and operational level. This paper aims at increasing the understanding of how decisions are made in GPD, with the intention of developing a model for decision support based on results from qualitative case studies. The aim of the presented research is to map GPD decisions in several industrial cases, in order to obtain an understanding of how decisions are made and how decision-making can be supported.

2. Background and related work

2.1 Globalisation, outsourcing and offshoring of product development

Globalisation and GPD represents a major transformation for business, and it applies to a broad range of industries [Eppinger and Chitkara 2006] and in todays connected world globalisations is not only desirable, but essential [Santos et al. 2004]. GPD is defined as a product development operation where development activities include distributed teams in multiple global locations [Eppinger and Chitkara 2006]. Outsourcing refers to companies sourcing a 3rd party supplier to deliver a certain task, product component or part of the PD process, while offshoring refers to companies expanding their own development activities in new locations, while maintaining ownership and control of the subsidiary [Hansen and Ahmed-Kristensen 2012]. Research related to GPD spreads over a variety of research areas in both management, innovation and operations research. However, a large body of research is focused on manufacturing, business processes and services outsourcing. More recently, the focus has shifted towards outsourcing and offshoring of innovation and R&D (i.e. [Bardhan 2006], [Gammeltoft 2006], [Andersson and Pedersen 2010], [Rilla and Squicciarini 2011]. Some of the general conclusions across the research are that GPD inevitably makes the product development organisation as well as the products much more complex and requires careful management [Zedtwitz et al. 2004].
Earlier research concerning GPD decisions has shown that there is often a high degree of uncertainty involved in making strategic decisions related to GPD [Piscopo et al. 2010], and that managers must

make decisions without sufficient information, and that the GPD decisions are often part of a costly learning-by-doing process. GPD is more complex than traditional product development, and therefore both task interfaces and product interfaces need to be clearly defined and managed. Companies establishing global production networks must also consider how to integrate R&D, since multiple interactions exist between production function and R&D function [Cheng et al. 2012], and establishing and managing international R&D networks and projects is non-trivial and a risky endeavour [Zedtwitz et al. 2004]. Furthermore, the cultural differences, the need for clear communication tools and a higher need for documentation and knowledge sharing across locations are additional examples of added management complexity in the global development organisation [Hansen and Ahmed-Kristensen 2011b].

2.2 Motivations and challenges in GPD

Motivations and challenges related to GPD decisions have been identified and described in preceding work [Hansen and Ahmed-Kristensen 2012], [Søndergaard and Ahmed-Kristensen 2014] along with a study of reasons for decision failure and why companies "back-source" globalised tasks. Regarding the motivational factors, reduction of the overall development costs is frequently mentioned as the main motivation for outsourcing and offshoring [Freytag and Mikkelsen 2007], [Makumbe et al. 2009], [Dekkers 2011]. However, cost reductions are only one of many possible motivations, others being access to new markets, proximity to existing production sites, access to knowledge and new skills, new competencies and resources, reduction of time to market, and flexibility or scalability of global resources [Søndergaard and Ahmed-Kristensen 2014]. Several studies have also identified the typical challenges companies face when they globalise product development tasks (i.e. [Zedtwitz et al. 2004], [Gammeltoft 2006], [Hansen and Ahmed-Kristensen 2011b]). The most frequently mentioned challenge in literature is cultural differences [Lewin and Peeters 2006], [Makumbe et al. 2009], [Hansen and Ahmed-Kristensen 2011b], which also has been found as one of the most difficult challenges to address. Other identified challenges include that expected cost savings are not met [Larsen et al. 2012], loss of control over outsourced activities [Barthelemy 2003] and decrease in product quality [Hansen and Ahmed-Kristensen 2011a]. As a consequence of these challenges, decisions are often changed over time, or in some cases the outsourcing or offshoring decision is even withdrawn altogether (called back-shoring, back-sourcing or re-shoring [Fratocchi et al. 2014]).

2.3 Decision making in GPD

Decision making in GPD is important because it is very costly to switch strategy and change strategic decisions after implementing them (i.e. going from outsourcing to offshoring, or moving a development department to a different location). Therefore the impact of strategic decisions is high, which to some degree is a paradox, because strategic GPD decisions are characterised by high uncertainty and limited information available, and they can be difficult to make with no previous experience. A consequence of GPD decisions often mentioned are hidden costs, which do not reveal themselves before the actual decision is implemented [Larsen et al. 2012], triggered by unforeseen added complexity. Often the assumptions or motivations ate the time of making the strategic decision are wrong, not taking into account hidden costs and other implications of the decisions (readiness, cultural, infrastructure, collaboration, lack of common vision etc.) and these are only revealed when the outsourcing or offshoring decision has already been implemented. Some of the moderating effects on the difference between expected and achieved cost savings from offshoring are organisational design and previous offshoring experience [Larsen et al. 2012]. Therefore making the right decisions is a central part of succeeding and reaping the benefits of GPD [Hansen and Ahmed-Kristensen 2012]. Much of existing decision-making theory is based on rational decision-making, and a range of different decision-making methods have been proposed for various types of decisions [Søndergaard and Ahmed-Kristensen 2014]. In a study of the role of information in strategic decision making, Citroen [2011] proposed a sequential model for a rational decision making process. However, rational decision-making presupposes that detailed information is available [Citroen 2011], and in GPD decisions, this is often not the case. GPD decisions are most likely associated with a very high degree of uncertainty, since there is little information or knowledge available to base the decisions upon [Shishank and Dekkers 2013]. Therefore,

a more experience-based approach is more likely to be useful for supporting GPD decisions. Based on studies of 136 cases of strategic decision-making [Cray et al. 1988] defined three types of decision processes: Sporadic, fluent and constricted. Sporadic processes tend to be informal, interrupted and lengthy. Fluent processes tend to be quicker, smoother and more formal. Constricted processes are bound by formal structures, proceed around a single individual and are made at lower levels of organization. These notions are useful for characterising strategic decisions in GPD and are used here for analysis of the decision cases.

3. Research aim and methodology

3.1 Research aim and research questions

The overall aim of the research is to increase the understanding of how GPD decisions are made, and particularly to identify which information is needed to make such decisions and which existing methods are utilised. The goal is to reduce uncertainty in the decision making process, and to highlight essential information which can support decision makers, thereby reducing risk and negative impact of implementing GPD decisions. To achieve this goal, answers to the following research questions are pursued:

- How are decisions related to GPD made, and which information is used to inform these decisions?
- Which methods can be used to support decision-making processes and assess decision parameters?
- How can decision processes be supported based on experience and best practice?

3.2 Methodology

The research presented here is based on the Design Research Methodology (DRM) framework by [Blessing and Chakrabarti 2009]. In this paper we are focusing specifically on the Descriptive study I and on the Prescriptive study I. However, for clarity, a brief description of each of the phases is presented here. The overall research structure is shown in Figure 1.

In the research clarification phase, an extensive literature review as well as review of previous case data was conducted, including analysis of empirical data from a previous research project (6 cases from 2010-2012, [Hansen and Ahmed-Kristensen 2012]). Analysis of this data was combined with a study of statistical data from Danish companies involved in outsourcing and offshoring [Søndergaard and Ahmed-Kristensen 2014]. In this initial phase of the research, motivations and challenges for the decisions were identified together with different decision methods related to GPD and to outsourcing and offshoring decisions. The Descriptive Study 1 (DSI) is based on data from industrial cases, with the main data source being case studies conducted in four Danish engineering companies in 2014-2015. All case companies had outsourced and offshored product development tasks within the past 10 years. Analysis of the cases (based on analysis of single decisions made based on a range of different decision types) led to an understanding of primarily three central questions: 1) Which motivations had led to certain types of decisions. 2) Which information has been used to support certain types of decisions? 3) Which methods had been applied when making the single decisions (if any)? In the Prescriptive Study I (PSI) phase, all information and findings gathered in the DS1 phase are synthesised and these are used as a base for developing a decision support tool where a conceptual frame for decision support tool (based on facilitated interactive decision making workshops) has been developed. The tool provides decision makers with recommendations and suggestions for better decision making based on previous experiences from the studies cases. At the time of writing, this tool is at a conceptual stage, and has been tested as a conceptual framework with industry. The Descriptive Study II (DSII) phase derives conclusions from using the tool for decision support and the study will be based on validation and testing in collaboration with decision makers in real decision scenarios.

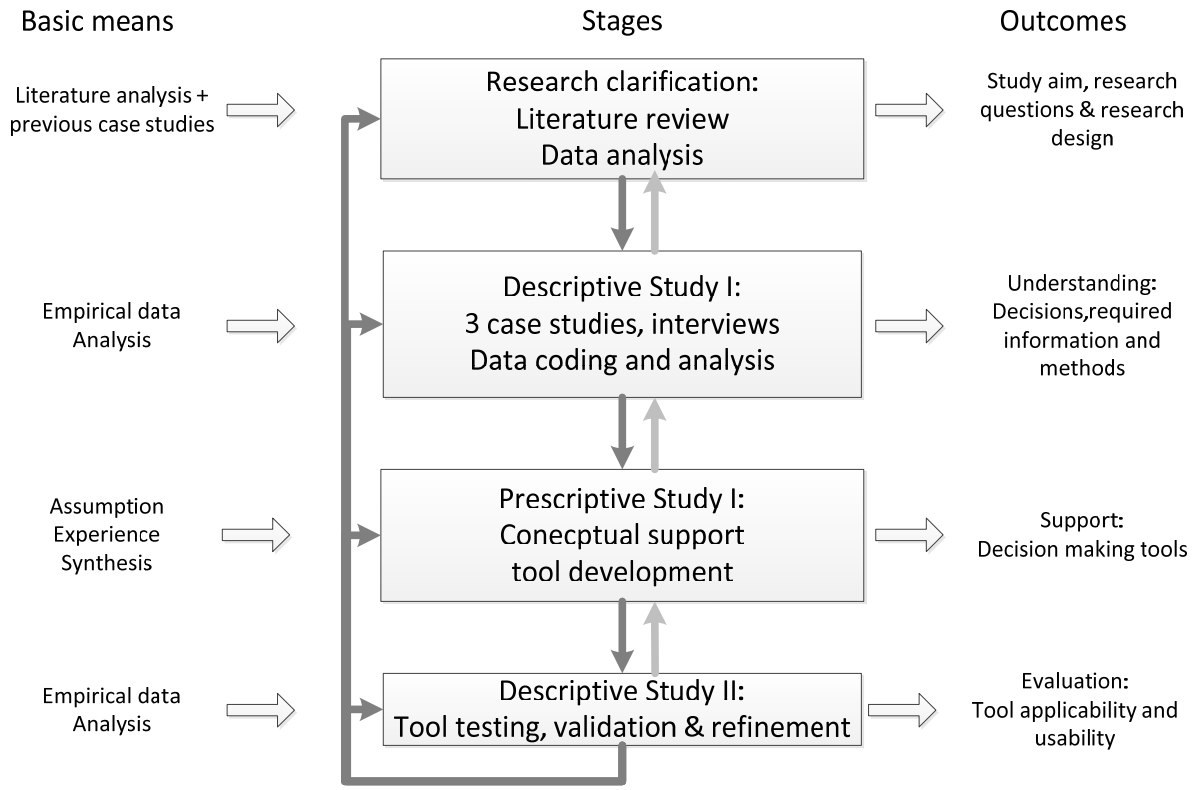

Figure 1. DRM, adapted from [Blessing and Chakrabarti 2009]

3.3 Case studies and interviews

The methodology is driven by the research questions, and given the exploratory nature of the research a case study approach was selected as the primary method, primarily for its relevance in answering "how" questions [Yin 2009]. The multiple-case design [Yin 2009] was chosen for the ability to compare across the cases, looking for patterns and similarities. The selection for case companies was that they had established development sites globally and had already worked with global development projects for a period. Semi-structured interviews are the main source of data collection, and interviews were carried out using an interview guide based on decision involvement and level. The data analysis was built around a framework including five key steps: 1.Transcription of interviews; 2. Identifying a coding framework (based on literature); 3.Coding of the data; 4.Identifying themes from codes, and 5.Mapping of decisions and interpretations of the coded data.

4. Data collection & analysis

Data collection consisted of 15 interviews, carried out over a 6 month period in Denmark, China and Malaysia. Table 1 gives an overview of the three cases companies, their characteristics, key decisions and key decision outcomes.

Table 1. Case study overview

Case	# of inter-views	Location	Industry	# of employees	Key decisions	Key outcomes
A	11	Denmark, China, Malaysia	Medical devices & healthcare products	2.300	Open development centres in China and Malaysia	Risk reduction in NPD Overall R&D cost reductions
B	2	Denmark, China	Industrial pumps and applications	18.000	Re-organise global organisation for scalability	Develop competencies in global sites Scalability for global projects
C	1	Denmark	Analytical equipment (food industry)	1.300	Open development centre in China	Overall R&D cost reductions

Table 2 shows the interviewees from the case-companies, the main drivers for GPD decisions, types of decisions made, tasks outsourced and the primary mode of GDP. In all cases, the GPD outsourcing and offshoring was to locations where the companies had already established production. Case A and C had both outsourced and offshored development tasks, while case B had only offshored, keeping the activities within the organisation.

Table 2. Case study interviews & key results

	Case A	Case B	Case C
Interviewees	• 2 VP´s: (CCO and VP Asia Operations) • 3 Project managers • 3 Senior R&D engineers • 2 R&D engineers • 1 Senior Q&A engineer • 1 Process engineer	• 1 Global program manager 1 D&E director (China)	• 1 VP, Product Innovation
Main drivers	• Cost reductions • Development closer to production • Risk reduction in NPD	• Scalability of resource • Creating centres of excellence in global location • Re-organisation to fit global operation	• Cost reductions • Development closer to production • Access to new resources
Tasks outsourced and offshored	• Non-core competencies are outsourced/offshored first (i.e. production) • Core competencies kept in HQ • Later stages of product development are globalised first	• Offshored specific competencies to global sites • Gather technical expertise in global delivery units	• Non-core competencies are outsourced/offshored first (i.e. production) • Core competencies kept in HQ • Later stages of product development are globalised first
Primary mode of globalisation	• Offshoring (product development) and outsourcing (component/module development)	• Offshoring to own development sites	• Mainly offshoring (development centres in Asia) • Outsourcing of software development

The majority of interviews (and majority of decision examples) are from Case A, as this was the main company studied. Case B and C supplement the findings from the main case, and allow for comparison of similarity across cases. Based on the transcribed and coded interviews, single decisions were identified and mapped from the cases. Whenever a single decision was identified in the interview data, this decision was singled out and mapped according to code categories. 51 different decisions were identified. Figure 2 shows an example of a mapped decision.

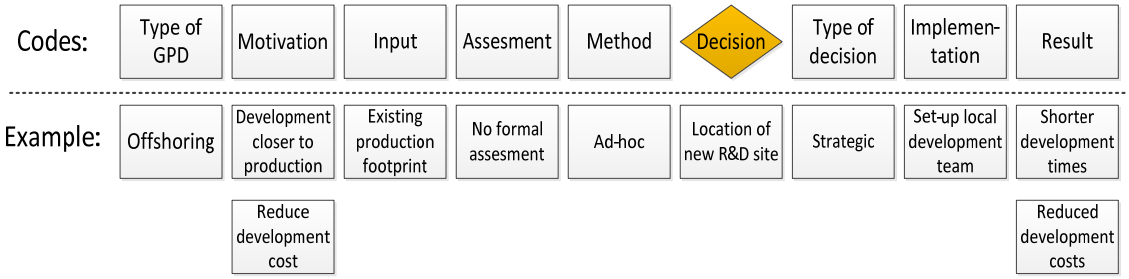

Figure 2. Example of a mapped and coded decision from interview data

5. Results: Descriptive study I

Across all 51 decisions, the decisions were categorised into decision types, and sub-sequentially these decision types were analysed concerning which motivations, methods and information were used for the different decisions.

5.1 Decision types and decision methods

Figure 3 shows an overview of all decisions, with the decision type on the x-axis, and the method applied for the decision on the y-axis. Each count represents one mapped decision. The most frequent decisions were outsourcing (10) and offshoring (9) decisions, with other decisions including decisions about organisational design (7), process design (7), decisions about creating distributed design teams (5), market driven decisions (4), location decisions (3), product design decisions (2), production design decisions (2) and two decisions were about cancelling a global project.

The chart shows that across all decision types, often no specific method has been applied for making the decisions. The methods identified for each decision type are the primary methods that could be identified from the interview data, but not necessarily mutually exlclusive, i.e. the primary method identified could be a risk assesment, but the decision might also have used design reviews. Especially offshoring decisions are made on an ad-hoc basis, which could be explained by the fact that when the companies are outsourcing, they keep the activities within control, and therefore it is easier to make corrective actions after implementing the decisions. Some of the identified methods that had been applied were the use of business cases, feasibility studies and resource planning, and in the outsourcing decisions, these are often based on a structured vendor selection process, where a weighting criteria is used for selecting between possible suppliers.

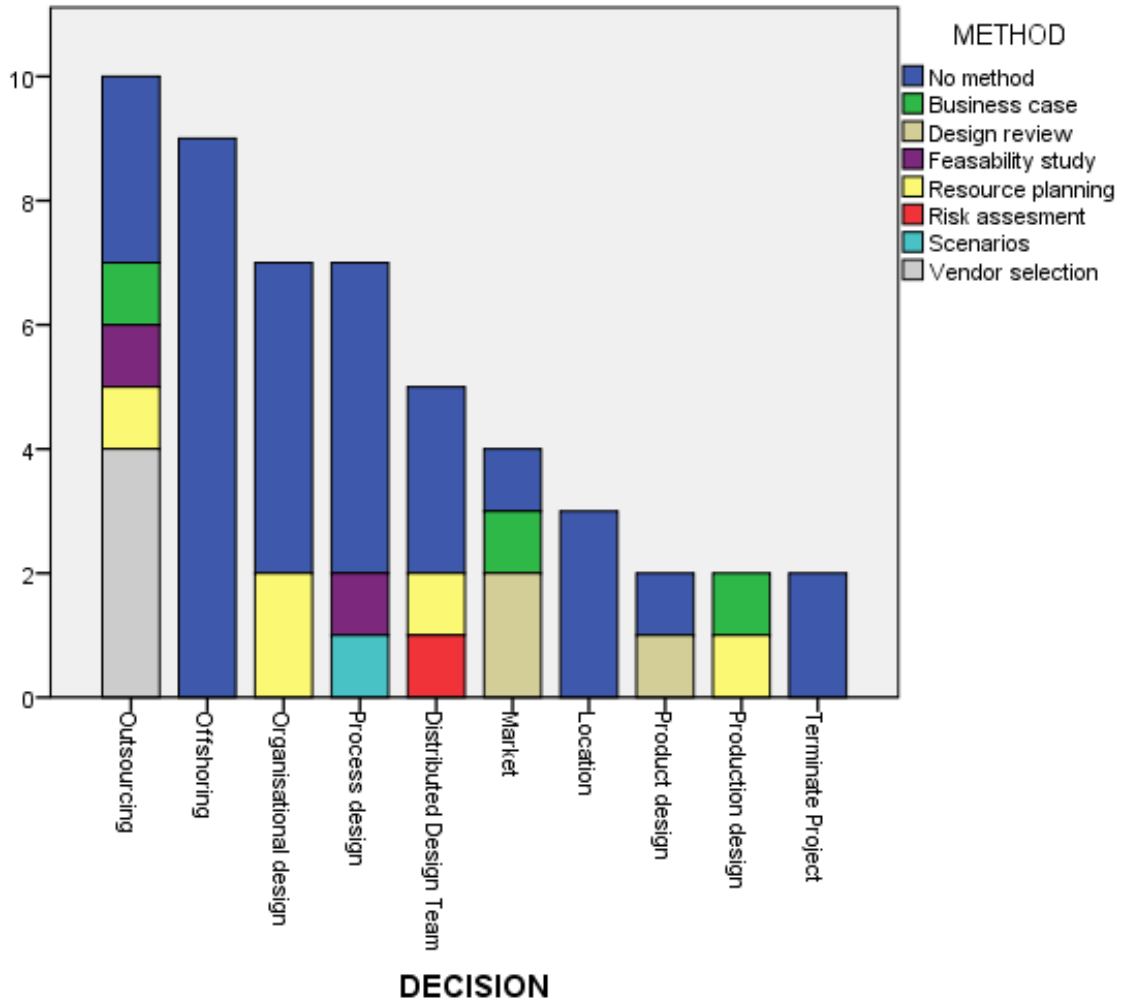

Figure 3. Methods applied for decision types

5.2 Decision types and decision information

Figure 4 shows a comparison of decision types and the information for making these decisions. A fairly broad variety of input information for the individual decisions is identified, however some patterns emerge. Market information is used as information across many decision types, indicating that many of the GPD decisions are triggered by changes in the market, (i.e. market needs or market opportunities). The results also show that the existing footprint of the company play a central role in offshoring decisions and location decisions, where the decision is based on where the company already had facilities in place (existing global production sites or subsidiaries). Outsourcing decisions are often based on and assessment of competencies (sourcing of competencies that the company does not have in-house) and specific requirements. Previous experience was the central information in one offshoring decision, and informed decisions regarding changes of organisational design or process design.

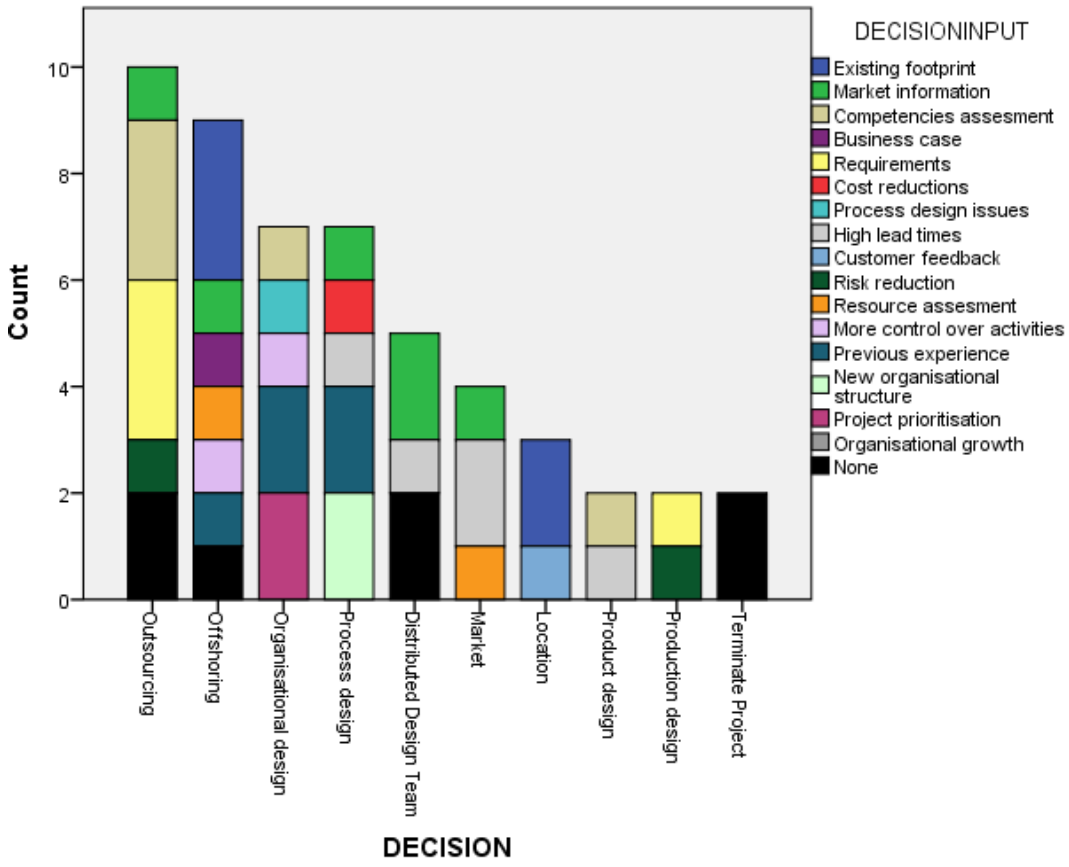

Figure 4. Decision types and decision input

5.3 Discussion of results

Analysis of the 51 decisions showed that GPD decisions are often made in a rather unstructured and ad-hoc manner, and referring back to [Cray et al. 1988] they can in many cases be characterised as sporadic decisions (informal and lengthy decision processes). Outsourcing decisions appear to have applied structured methods more frequently than others, indicating that there is a higher need for control and planning for these types of decisions. These decisions were also more structured and formal, what can be characterised as a more fluid process. An interesting result of the comparison of decision types and methods identified is that for offshoring and location decisions no methods were identified from the data. An explanation for this could be that the offshoring and location decisions were all based on previous experience and existing footprint; offshoring took place to locations where production was already established. Therefore, the location choice and offshoring to these locations was a natural evolvement in all three cases. GPD decisions are often characterised by high uncertainty, and hence many of the more mathematical or rational decision making methods are not applicable, because many of these methods require well-known alternatives, weighting of alternatives etc. For some GPD decisions (i.e. ranking alternative locations or different vendors for outsourcing), this can be applied, however, for many other decisions the structured information for weighing alternatives is not present. Therefore, it can also be difficult to make a detailed business case or risk assessments. The findings indicate that decision-making in GPD, under high uncertainty needs some structured input, and If decision makers do not have a lot of experience, they could benefit from best practices and other examples from previous cases as information input for their decision process. A decision-support tool

should therefore facilitate a more fluid and less sporadic decision process, and to bring in and build on previous experience, it should include best practice and empirical examples in the decision process.

6. Tool development (Prescriptive study I)

Based on the findings described in the previous section, the decision types and patterns observes were used as a base for developing a conceptual frame for a decision support tool. This section describes the initial concept of a decision-support tool based on company experience and best practice.

6.1 Decision support process

The tool is based around a general decisions process, including the most common steps that are involved in such a process, including identification of the issue to be decided upon, definition of the different options, identification of the information needed to make the decisions, suggested methods for making the assessment and decision, and the decision itself. The process diagram for the support is based on general process patterns found in the analysed decisions. However, since the decision process is rarely linear, the different input and output elements can be applied at different times. Some of the steps in the flowchart might also not be relevant to one organisation or decision situation, while they might be central in others. The input to trigger information gathering and discussion in each step is based on previous research, which will ensure that previous experience (from other cases previously studied) can inform the decision making process.

6.2 Information input & result output

To facilitate the decision process and trigger questions in each phase, there is knowledge input for each phase. The input in each phase of the decision process is based on two sources: The information that the decision makers put into the decision, and information cards based on the previous research (i.e. examples of existing motivations, scenarios, or methods that have been used in other decision cases).
The purpose of having the information input throughout the process is to allow for an individualised decision process where the decision makers build their own scenarios, but at the same time incorporate best practice and knowledge from other GPD decisions presented in this study. The outcomes of the decision support-tool (see Figure 5) are scenario descriptions (mapping the decisions scenario) any questions that need to be addressed, and finally action plans. Action plans should define either how to implement the decisions, or alternatively the action plans can describe which further actions must be taken before reaching to a final decision. The output documents support visualisation of the decision and create a degree of traceability for the decision and the rationale that went into making the decision.

7. Tool validation (Descriptive study II)

In order to test and validate the tools usability for decision-support, it should be tested in a real-life environment, in a company context. At the time of writing, such validation and refinement of the decision-support is planned. However, some general findings can already be pointed out at this point, based on a test run at an industrial workshop with 10 participants from different companies who were asked to use the decision-support tool and apply it to a real-case example. The participants said that the support cards with methods, examples and challenges were useful for triggering discussions about the decision. One of the questions raised was regarding users: Who will be using the tool; will it be top managers making the final decision, or the team providing the decision input to the top managers? The way the tool is structured should reflect that, and further development and refinement of the tool requires more thorough feedback on the tool from decision makers.

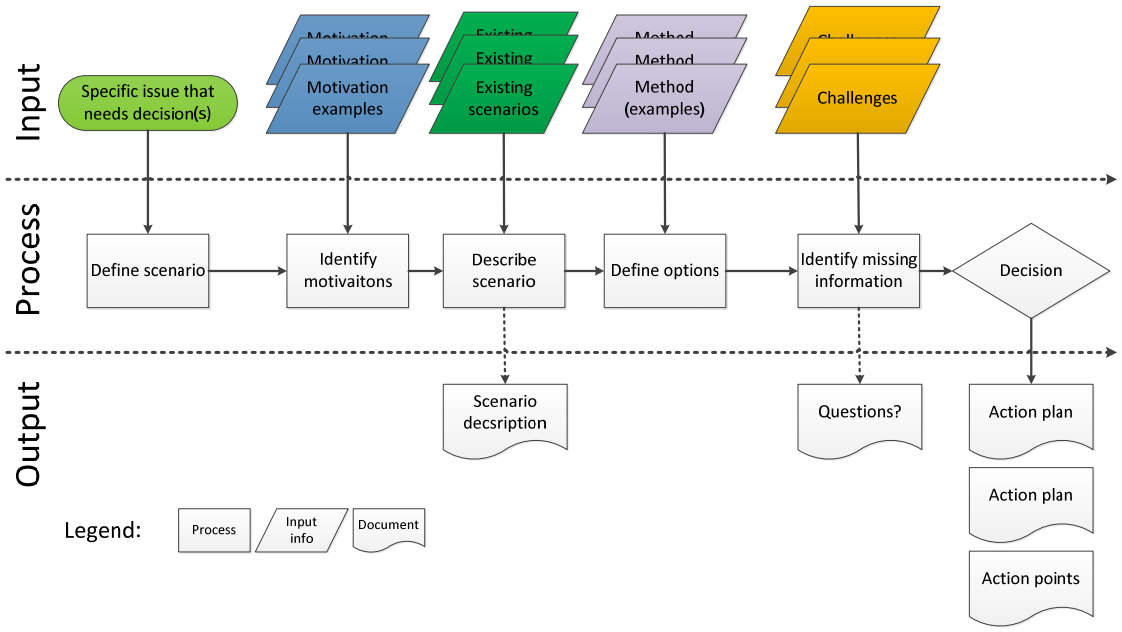

Figure 5. Proposed overall structure of decision support tool

8. Conclusion

The paper highlights how decision-making in GPD often involves a high degree of uncertainty, is characterised by a learning-by-doing process, and often could benefit from previous experience. Through a multiple case study in Danish engineering manufacturing companies involved in GPD, this paper identifies a range of decision types, and investigates which motivations, information input and methods relate to which types of decisions. GPD decisions are often made under high uncertainty, and therefore a structured and method-based process is not always used for decision-making. Based on the results, this paper outlines a conceptual decision support-tool, which can make decision processes less sporadic and more fluid. The suggested support tool is based on scenario building, using information inputs such as motivations, methods and challenges from case-examples to trigger questions to be addressed when making decisions. The tool should also allow for customisation and bringing in earlier experiences and building a decision repository over time (inspired by CBR). For managers and decision makers with limited experience, such a tool can improve the understanding of which information should be foundation for specific decision types, and help them to make better assessments when making GPD decisions. The results can contribute to education at both university and practitioner level. At university level, an understanding of the challenges and pitfalls in GPD should be included in the learning curriculum for design and product development engineers, as they will most likely work in a globalised development environment in the future, and need to be prepared for this environment. For education at a professional level, the research can contribute to teaching GPD and decision dynamics to practitioners who have little or no GPD experience, which are competences that are increasingly relevant as design becomes more distributed.

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