Towards a contextual model of software engineering capabilities: Factors affecting team performance

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***Abstract*—A prevalent research stream in the information systems domain is founded on the rationale that organizations need to establish and manage specific IT capabilities to achieve competitive advantage. More recently, research efforts have shifted from investigating organizational-level capabilities towards identifying team capabilities in order to support modern approaches to software engineering. The research at hand aims to identify contextual factors which influence these software engineering capabilities required by teams to achieve superior performance. To this end, we adopt a mixed-methods approach conducting a tertiary study and an empirical research component involving six domain experts. The tertiary study results in a taxonomy of 56 contextual factors which are then reduced and validated with regards to their relevance to software engineering teams through a Q-Sort ranking exercise and a subsequent focus group session. This results in a subset of 15 items which together form a contextual model of software engineering team capabilities along the dimensions technology, organization and environment. The paper discusses the mature research stream on information systems context in the new light of modern software engineering approaches. The resulting contextual model is of value to researchers and practitioners when analyzing their team context and deciding in which capabilities to invest.**

Keywords—contextual model, software engineering teams, team capabilities, focus group, tertiary study, information systems

I. Introduction

Management of IT capabilities has long been seen as a means to improving organizational performance. Information Systems (IS) theories such as the resource-based view [1] are grounded on the rationale that firm resources like capabilities and assets enable organizations to achieve competitive advantage. Analogously, more recent research has argued that the possession of certain team capabilities will enable software engineering teams to improve their team performance [2]. This focus is especially relevant considering the rise of modern software development approaches like Agile or DevOps, which rely on decentralized decision-making structures and thus heavily depend on identifying and building effective team capabilities to achieve superior performance [3].

Capabilities are often described as idiosyncratic [4] since they are being shaped by organizational context and history. Although a vast amount of research has been conducted on capabilities that improve team performance [3], to the best of our knowledge, there is little research available which has explicitly taken into account how organizational context shapes the capabilities necessary to achieve this. A better understanding of these contextual factors is expected to benefit decision-makers in IT organizations when choosing which team capabilities to invest in and is therefore presumed to lead to an increase in organizational and team performance. On the other hand, not taking the organizational context into account when using capability-based planning approaches may lead to unsuccessful investment choices which do not result in increased levels of performance. The research at hand is thus based on the logical proposition that engineering team capabilities need to be adapted to the organizational context in order to positively influence team performance (Fig. 1).

The idea that organizational context affects information systems has prevailed for many years. Most prominently, classic contingency theory argues that an organization, the organizational environment, and organizational performance are closely interrelated. Management, implementation, structure and development of IS should therefore be suited to a set of contingency variables in order to improve performance [5]. This contradicts prior management theories which often promote a "one best way" to organize. The logical proposition of this research is therefore a direct analogy to the premise of contingency theory as depicted by Weill & Olson [5].

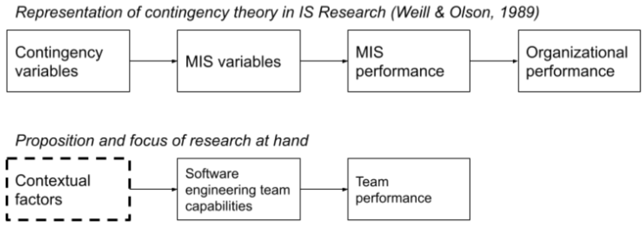

Fig. 1. Relation of research proposition to contingency theory

The focus of this paper as delineated in Fig. 1 is to investigate and identify contextual factors which influence software engineering team capabilities. Although there is a multitude of literature on software engineering capabilities and a large stream of research on organizational and IS context variables available, to the best of our knowledge, no prior research has investigated the specific relationship between these two domains. However, related research has been conducted by Brown & Brown [6] who conducted an exploratory investigation on contextual factors influencing Strategic Information Systems Plan Implementation and Shin & Edington [7] who present a framework for contextual factors affecting information technology implementation.

The research at hand follows the question *"Which contextual factors influence the software engineering team capabilities*

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required to improve performance?". Subsequently, we aim to conceptualize the organizational context in the light of software engineering capabilities and to ultimately create a contextual model of these capabilities which may help researchers and IT decision-makers in analyzing a team's context and deciding which capabilities to invest in. In order to answer the research question, we have adopted a mixed-method research approach: We first conduct a tertiary study in which we synthesize the results of five literature reviews on contextual factors of information systems. Accordingly, we provide an overview of contextual factors mentioned in extant literature. The contextual factors are then reduced and validated by six domain experts in a two-step process involving an individual Q-Sort exercise and a focus group study in which these factors are ranked and discussed based on their relevance to modern software engineering teams. This results in a contextual model of 15 factors which are presumed to have a strong influence on software engineering capabilities.

The remainder of this paper is structured as follows: In section II we present the process and results of the tertiary study on contextual factors of IS. Section III describes the methodology of the Q-Sort exercise and focus group study among domain experts. The results of this empirical research component including the contextual model are presented in section IV. We then discuss our findings in the light of their contributions and limitations and discuss possibilities for future research (section V). Section VI concludes this paper.

II. Tertiary Study

To the best of our knowledge, there is no literature available explicitly addressing the context of software engineering team capabilities, although the topic of context in information systems has long been recognized in IS research [8]. For this reason, the vast body of knowledge available in the IS domain was considered an adequate source of information covering generic contextual factors from which the more specific factors for software engineering capabilities can be deducted. A tertiary study was therefore considered to be a suitable technique to further explore this mature research field. The study had the primary objective to come up with a taxonomy of contextual factors of software engineering teams and was initially conducted while using variations of the keyword search: *"Organizational/ Company/ Firm AND context(ual) /environment(al) AND fit/ alignment/ contingent/ contingency AND performance/ success"*. Papers were extracted from multiple databases including Information Systems literature such as AISeL, Scopus, IEEE Xplore and Google Scholar. The keywords were agreed between the authors beforehand. The search was then conducted by the first author and the results were later discussed with the other two authors. The search was focused on papers containing literature reviews which were published in journals or conference proceedings. Due to a lack of research specifically addressing contextual factors of software engineering teams or capabilities, we searched for papers that discussed the context of information systems in general. In later stages of the search, only parts of the above-mentioned search string or variations of it were used. We also added papers through snowballing and included papers that were previously known to the authors, and which fit our research objective. This resulted in a set of five papers containing literature reviews on contextual factors of information systems [5], [7]–[10]. The papers were published between 1989 and 2011 and thus covered a timeframe of 22 years.

The literature search did not follow a systematic approach because no keyword combination could be identified which provided a scope that was neither too broad nor too shallow to serve as a basis for a systematic review. We therefore decided to focus on the goal of reaching theoretical saturation instead of data saturation as proposed in Grounded Theory [11]. Theoretical saturation is achieved once no new concepts or links arise during the data analysis. Previous literature has suggested that this Grounded Theory approach is not only suitable for analyzing empirical data is also useful while reviewing literature [11].

The five papers were imported into the qualitative data analysis tool Atlas TI and were coded by assigning labels to chunks of text [11]. The labels were then merged where necessary and grouped into categories. The data items to be collected through this process were the contextual factors mentioned in the papers. Contextual factors were extracted if they satisfied three criteria: Firstly, the factors had to be specific, inferring that container variables such as "*socio-technical factors*" were excluded from the collection. Secondly, the factors had to be qualitatively or quantitatively measurable which means that specific actions such as "*strategy and goal setting*" were equally not included in our overview. These two criteria were employed due to the fact that the resulting contextual model should contain measurable and specific factors in order to be of use to end-users. Furthermore, the items were to be evaluated by a focus group in the later stages of this research (see section III.B) who needed to thoroughly understand the factors and rank them according to their strength of influence. Lastly, the items had to be positioned outside of software engineering teams which is a direct derivative of the research question. This means that items such as *"user participation"* were not included since they partially describe activities that take place within a team and thus cannot be considered contextual factors in the light of this research.

This process resulted in a final overview of 56 Factors which were grouped into the categories *Technology*, *Organization* and *Environment*. This categorization is based on the well-known Technology-Organization-Environment framework from DePietro et al. [12] who model the firm context along these dimensions and argue that technology, organization and environment influence the process in which organizations adopt and implement technological innovations.

During the categorization of items, we interpreted the last category to include all factors that were positioned outside of the organization, thus constituting the external environment. This process led to a set of 11 factors describing the technological context, a set of 36 factors that were part of the organizational context and 9 factors pertaining to the external environment. Due to the number of factors belonging to the organizational category, these factors were further classified into multiple subcategories. Lastly, we added a definition to each contextual factor, interpreting what the items mean in relation to software engineering teams[1]. An overview of all 56 contextual factors is shown in Fig. 2.

[1]For a complete overview of all contextual factors and their definition please refer to the Appendix.

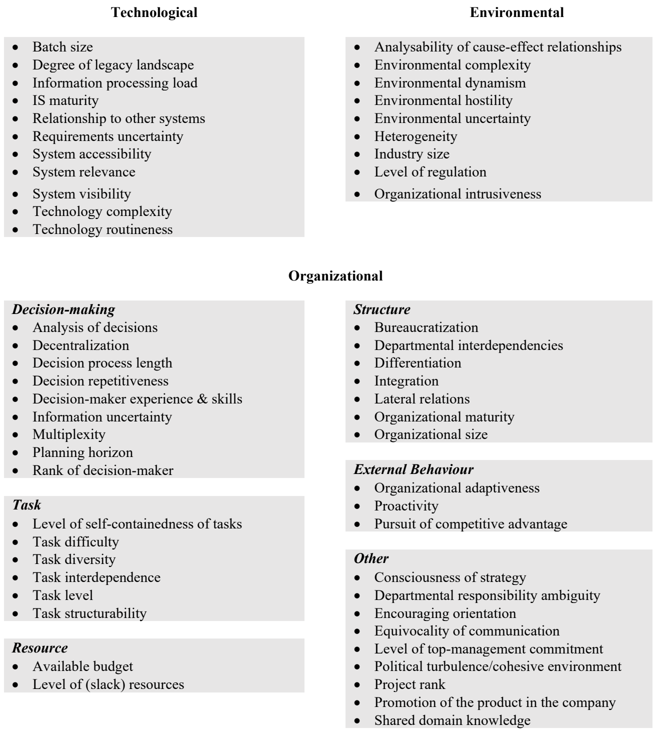

Fig. 2. Contextual factors extracted from the tertiary study.

A. *Technological context*

Technological contextual factors describe the state of the technology with which software engineering teams are working as well as the way in which the teams utilize this technology. Extant literature suggests that technology is determined by the maturity of its systems [10] and the extent of legacy systems involved in the landscape [7]. Related to this, the technological landscape may be exceptionally complex or structured simply [9]. A low level of technology routineness [9] can present software engineering teams with many exceptional problem cases that cannot be analyzed easily according to standard procedures and thus may require a special skillset.

Two other important factors encountered during the review are the batch size that is processed [9], describing the size of tasks which the team handles and the processing load of the system [8], [9] which determines the speed of the system. Furthermore, software engineering teams are affected by the clarity of requirements from users towards their system [8]. Additionally, technological systems may be highly interconnected to other systems or be largely freestanding [9]. Another important group of technological contextual factors is the accessibility, relevance and visibility of the system on which the team is working in the organization and towards stakeholders [10].

B. *Organizational context*

The tertiary study resulted in a vast variety of organizational context factors which were divided into six subcategories. Firstly, the organizational context is described by the way in which *decisions* are taken in the company. The position [8]–[10] and rank of the decision-maker [7], [8], [10] plays a central role in the organizational context. This is partially determined by whether decisions are taken at a central point in the organization, or the responsibility is distributed between multiple entities. Furthermore, the number of factors considered in the decision-making process (multiplexity) [9], the length of the process [8] and the manner in which the problem is analyzed [9] are considered part of the organizational context. Another set of organizational context factors are items describing the *structure* of the organization [5] such as its size [5] or maturity [8], [10]. Bureaucratized organizations are guided by formal rules and procedures and often possess many hierarchical layers [8]–[10]. The individual departments within the entity may be heavily dependent on each other or work independently from each other [7]–[9]. Additionally, they may be aligned in terms of policies and objectives (integration) [8]–[10] and may be similar or differ in terms of modus operandi such as planning horizons and goals orientation [8], [9].

The *tasks* on which the teams are working are influential in terms of their difficulty [8], [9] diversity [8], [9], and interdependence [10] but may also differ based on their structurability [9], [10], the level at which they are performed [9] and whether the team is working on them in functional specializations or product groups [9]. Another important category is the *external behavior* of the organization, describing to which extent the enterprise can adapt to changes in the environment [9], is proactive in taking actions and staying ahead of the competition [9] and the degree to which the organization pursues competitive advantage [8]. Organizational context is further specified by the availability of slack *resources* [7]–[10] and budget [7], [10]. Other factors resulting from the tertiary study are the consciousness of strategy among employees [7], [9], the degree to which responsibilities are clearly defined between the departments [10] and the clarity of communication [7], [9]. Furthermore, the degree to which organizations promote and encourage change among their employees [7], [10], as well as the level of top-management is committed [7] may influence the capabilities of software engineering teams. Changing prioritization of projects [7] as well as the rank of the software engineering team in the organization [10] may be equally influential. Lastly, the study suggests that the degree to which other departments in the company possess IT knowledge [7] may be an important part of the organizational context.

C. *Environmental context*

Factors which are positioned outside the organization were sorted into the environmental context category.

The organizational environment consists of several variables whose number and level of interdependence determine the environmental complexity. While some organizations are subject to a frequently changing environment, other organizational environments may be relatively stable [8], [9]. A related factor is the concept of environmental uncertainty describing the degree to which the environment can be predicted [8], [9]. Managers operating in environments with clear cause- and effect-relationships can rely on explicit data to answer questions. However, if the analyzability of cause- and effect relationships is rather low, it is often not clear what information is needed to answer a question [9]. Organizational environments may be heterogeneous or homogeneous, e.g. regarding product orientations, consumer characteristics, technologies and materials [9]. Furthermore, some environments may be particularly hostile due to the number and nature of competitors as well as due to threatening shortages [9]. Another factor describing the organizational environment is the level of regulation that is applied [9]. Based on the nature of the environment, organizations may decide to simply accept the information that is provided by the environment or may decide to actively intrude it by allocating resources to searching and manipulating the environment [9].

III. Methodology

The results of the tertiary study were validated and refined by means of an empirical study involving six domain experts. All of these experts worked for a Dutch consulting company advising on digital transformations and had vast experience with advising and coaching software engineering teams. Following a call for participants, the experts volunteered to take part in the study due to their experiences and their intrinsic interest in the topic. In terms of seniority, the focus group consisted of three principal consultants, two senior consultants and one consultant. One of the participants was female while the others were male.

The goal of this study was to discuss the items identified during the tertiary study specifically in the light of their influence towards software engineering teams and to identify the most important items to be included in the contextual model. The study consisted of two interconnected parts in each of which five of the six consultants participated.

A. Q-Sort individual analysis

The first part consisted of a quantitative evaluation in which the participants were asked to rank the factors depending on the strength of the influence which they believed these factors would have on software engineering team capabilities. To achieve this, the participants were sent an overview of all 56 contextual factors extracted from literature including the definition of each factor. They were then asked to sort the factors within each of the three categories by putting them on a digital Q-sort grid [13].

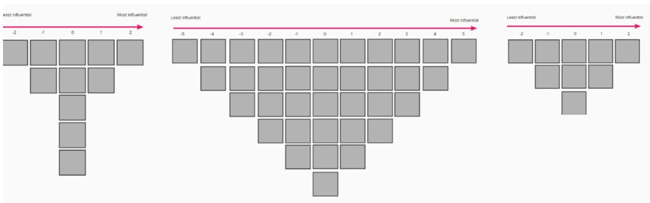

Fig. 3. Q-Sort grids for technological, organizational, and environmental factors (from left to right)

A Q-Sort allows the participant to rank items relative to each other by placing them on a grid which resembles the shape of a near-normal distribution. Due to the different amounts of factors per category, the shapes of the three Q-sort grids slightly deviated from one another as shown in Fig. 3. The Q-sort is a forced approach which means that the participants have to rank all items and can only use each position once [13]. The participants therefore must carefully select the items which they feel strongly about and place them at the outer ends of the grid. They can place a larger chunk of items which they are not particularly opinionated on towards the middle of the grid.

The items in the middle of the grid received the score 0 whereas the items on the outer ends of the grid received a positive or negative score relative to the size of the grid. The Q-Sort grids were placed on a digital whiteboard. Each participant received a separate invitation email to the study with a link to a personal whiteboard that could only be accessed by the researcher and the respective participant. After the participants had sorted the items, all scores which the participants had given towards a particular item were then gathered in an Excel sheet by the researcher and summed up to obtain a relative importance score. This score represented the average opinion of the participants. For example, if a participant had placed a particular item in the most right-hand column of the grid whereas another participant had placed the same item on the most left-hand side of the grid and all other participants placed the item in the middle, the item would receive a relative score of 0. In order to identify strong differences in opinions between the participants we also calculated the standard deviation of the importance scores.

This first part was done individually, and the participants were not allowed to communicate with each other during the exercise in order to avoid any form of bias.

B. Focus group study

The second part of this research directly builds on the results of the first round and consisted of a qualitative focus group session. A focus group is considered useful when ideas can be generated from group interaction and is frequently used for explaining phenomena without providing testable predictions [14]. Activity-based focus group discussions are often composed of two main stages [15]: First, a preparatory stage which is often led by the researchers and in which the material is laid out. The second stage of such a discussion is the actual group discussion between the participants.

In the research at hand, the Excel sheet containing the results of the Q-Sort exercise was used as a starting point for the focus group discussion. The participants were shown the final ranking of factors based on the previously calculated relative importance scores. The session was recorded with permission of all participants. During the discussion that followed, the participants debated how these scores originated, paying particular attention to factors with a high standard deviation (representing large gaps in opinions) and gave their own opinion on the ranking. Finally, the participants were asked to agree on a set of five factors per category which they considered to be most important. This was done in order to come up with a clear, comprehensible overview of items to be included in the contextual model. The inclusion of 15 items in total was considered an appropriate scope for the model since the number is manageable yet large enough to suitably represent all the three dimensions of the team capability context. The first author was present during the session and occasionally engaged in the group discussion by posing questions and making statements but did not actively participate in the decision-making process.

IV. Results

The primary results from both exercises are displayed in Tables 1-3, demonstrating the ranking of technological, organizational and environmental factors respectively. The first two columns display the results of the Q-Sort exercise, showing the relative importance score of each factor and their standard deviations. A high standard deviation means that the individual scores given by the experts to this factor deviated strongly which infers that the participants had widely differing opinions on the strength of the influence of this factor. A high standard deviation thus also suggests that the relative importance score is less meaningful. For this reason, these factors were often addressed during the focus group discussion. The third column marks the five factors which the experts ultimately deemed to be the most important following the discussion and chose to be included in the contextual model. The tables include all contextual factors from the highest-ranking relative importance scores down to the fifth factor which the focus group chose to include in their final set of most influential factors.[2] Since the focus group session directly built on the results of the Q-Sort, the results of this second part are considered the final ranking of factors in our study.

Due to the different sizes of the grids and subsequently the different maximum and minimum scores of the outer ends of the grids, it is important to note that relative importance scores can only be compared within the same category but not between categories. To make interpretation of these scores easier we have added the possible maximum and minimum scores to each category, assuming all participants had agreed and put a factor on the same outmost end of the grid.

During the focus group session, the participants discussed the results of all three categories consecutively. They were primarily interested in discussing factors on which the scores from the first round indicated a strong variance in opinions regarding their strength of influence. For this reason, the group did not only consider the standard deviation which was previously calculated but also added a score indicating the difference between the highest and the lowest score in their evaluation. Ultimately, the factors included in the discussion were the relative importance score, the average score, the difference between the highest and lowest ranking score and the standard deviation.[2] When asked to choose the five most important factors per category, the group generally chose to work through the tables from the top towards the bottom, starting with the highest relative importance score. For each factor, they discussed whether it was justified to include it in the contextual model. They proceeded with this process until they had chosen five factors. In some cases, the group deviated from this approach and moved directly towards discussing items which they found highly relevant, or which caught their attention due to their scores.

The focus group argued that the resulting contextual model should include five factors per category that were largely independent from each other and together should suitably represent their respective context category. They frequently pointed out that many of the factors were interrelated and therefore decided to exclude multiple items from the final selection, that were considered to be strongly related to another factor, even though they had a high relative importance score.

A. *Technological context*

The focus group agreed with the outcome of the Q-Sort exercise that the *relationship of a system to other systems* and the *uncertainty of requirements* were very important factors influencing the capabilities which software engineering teams need to be successful. When discussing the item *degree of legacy landscape,* the group pointed out that this concept was a part of *technology complexity* which they also deemed to be important. The first item was therefore omitted while the latter was included in the contextual model. The experts additionally examined whether the factors were specific enough to be evaluated in follow-up research or if they were to be included in an assessment. Subsequently, the item *IS maturity* was not included because the concept was deemed to be too vague. The focus group agreed with the importance of the three succeeding factors and therefore included *technology complexity*, *technology routineness* and *system relevance* in the contextual model.

TABLE I. TECHNOLOGICAL CONTEXT FACTOR RANKING

Factor	Q-Sort		Focus group session
	Relative importance score*	***Standard Deviation***	***Final ranking***
Relationship to other systems	+ 5	0,9	1.
Requirements uncertainty	+ 4	1,0	2.
Degree of legacy landscape	+ 3	0,5	
IS maturity	+ 2	0,5	
Technology complexity	+ 1	1,0	3.
Technology routineness	+ 1	0,7	4.
System relevance	- 1	0,7	5.

*Possible maximum/minimum score: +/- 10

B. *Organizational context*

When discussing the organizational category, the group debated to which extent they considered *(de)centralization* to be a part of the context. They agreed that this factor was highly important but rather considered it to be a prerequisite to modern software engineering approaches like Agile or DevOps which require decentralized decision-making structures to function effectively. The experts therefore thought that this item should not be considered part of the teams' context. The group however pointed out that (de)centralization was related to *departmental responsibility ambiguity* and decided to include the latter item in their selection. They also agreed on the importance of an organization's ability to *adapt to changing circumstances* and their *proactivity* in taking action and included both factors in the contextual model. The participants agreed that *departmental interdependencies* were very important and strongly affected software engineering teams. They furthermore thought that this factor was analogous to *relationships to other systems* from the technological category which was also deemed to be highly important. Moreover, the group discussed the relationship of this item to the *decision-process length*. Ultimately, they agreed that less interdependencies between departments would likely lead to a shorter decision-process length but thought that the first item in its entirety was more important than the latter. Lastly, the focus group discussed the importance of the *rank of a decision-maker* for software teams. While the participants initially thought this factor to be influential, they soon agreed that the message which the decision-makers conveyed was

[2] Due to space limitations, a complete overview of the results and their scores including factors with a lower ranking relative importance score than the five items chosen by the focus group can be requested from the authors.

more important for software teams than their rank. They subsequently chose the factor *encouraging orientation* as a fifth factor in the contextual model. This factor represented the message which the group thought managers need to represent towards their teams and to which teams need to adjust to.

TABLE II. ORGANIZATIONAL CONTEXT FACTOR RANKING

Factor	**Q-Sort**		**Focus group session**
	Relative importance score*	***Standard Deviation***	***Final ranking***
(De)centralization	+16	1,3	
Organizational adaptiveness	+12	1,7	1.
Proactivity	+ 9	2,0	2.
Departmental responsibility ambiguity	+ 9	1,6	3.
Decision process length	+ 7	2,8	
Task interdependence	+ 7	2,3	
Consciousness of strategy	+ 6	2,4	
Departmental interdependencies	+ 6	2,5	4.
Rank of decision-maker	+ 5	1,7	
Encouraging orientation	+ 5	1,4	5.

* Possible maximum/minimum score: +/- 25

C. *Environmental context*

The discussion about environmental context factors was centered around the five highest ranking factors from the Q-Sort exercise. The focus group agreed that these factors were indeed highly relevant and that software teams needed to develop capabilities to deal with these influences.

TABLE III. ENVIRONMENTAL CONTEXT FACTOR RANKING

Factor	**Q-Sort**		**Focus group session**
	Relative importance score*	***Standard Deviation***	***Final ranking***
Environmental dynamism	+ 6	0,7	1.
Level of regulation	+ 4	0,4	2.
Environmental uncertainty	+ 2	0,8	3.
Analysability of cause-effect relationships	+ 2	1,4	4.
Environmental hostility	0	0,6	5.

* Possible maximum/minimum score: +/- 10

D. *Contextual model*

As described previously, the focus group session was the last step in the research process and resulted in a subset of 15 factors. These items form a contextual model of software engineering capabilities as depicted in Fig. 4. The factors included are deemed to be highly relevant to software engineering teams and together represent the context which influences the team capabilities required to improve performance. All items included in the model are specific and can be measured qualitatively or quantitatively. Therefore, the different factors can be easily analyzed by practitioners and researchers.

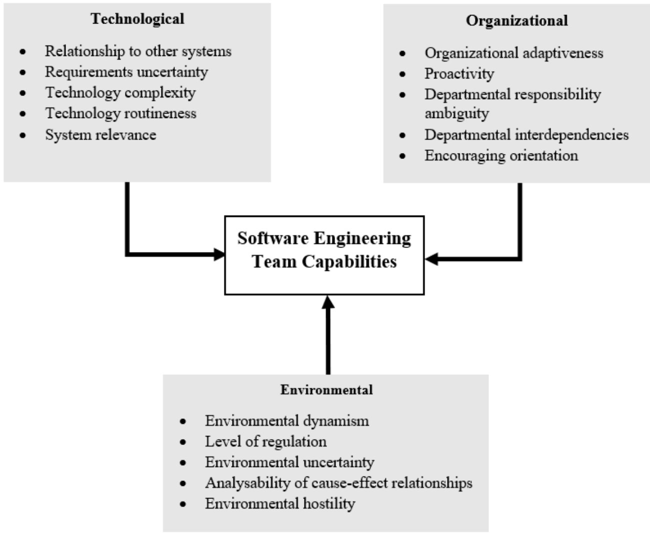

Fig. 4. Contextual model of software engineering capabilities resulting from this research.

V. DISCUSSION AND LIMIATIONS

The paper at hand investigated which contextual factors influence software engineering team capabilities. This was done by conducting a tertiary review on contextual factors of information systems and presenting them in the light of the Technology-Organization-Environment model [12]. The results were further refined by means of a Q-Sort exercise and a focus group study involving a total of six experts on digital transformations who discussed the items in the light of their influence on software engineering team capabilities. This resulted in a final set of 15 factors which were selected to be included in a contextual model.

During the tertiary study it was found that the vast majority of factors encountered belonged to the organizational category. Significantly less factors were found that belonged to the technological and environmental categories, which suggests that the business-related research field on organizational context is the most thoroughly addressed of the three categories. In addition, the items in the environmental category had a higher abstraction level than the other two groups and displayed less overlap. Possibly for this reason the experts were quick to agree with the five highest ranking factors from this category whereas they had more elaborate discussions on the technological and organizational context factors. This implies that the resulting contextual model may cover the environmental category more thoroughly compared to the other two categories, considering that the environmental factors were conceptually broader and less of the factors encountered in literature were eliminated from the model.

It is notable that the items which were included in the contextual model were not necessarily the factors that were mentioned most frequently in literature or were ranked as most important during the Q-Sort exercise. During the discussions, the participants frequently pointed out that many of the items were interrelated or belonged together. For this reason, some factors which previously had received a high relative importance score were omitted from the model.

Furthermore, the focus group paid special attention to factors which displayed a high standard deviation during the Q-Sort exercise. In many cases, this deviation resulted from differing interpretations of the same factor or the relationships which this factor had towards software teams. While discussing these differences, the individual opinions converged and the focus group participants jointly chose the 15 factors which were ultimately included in the contextual model.

A. Contributions to research and practice

The results of this research contribute to both theory and practice. Firstly, the paper at hand summarizes the contextual factors encountered in prior research by means of a tertiary study and presents a taxonomy of 56 factors on technological, organizational and environmental context factors. Although there already was a mature research stream on the context of information systems available, much of the knowledge on this topic is dated and extant literature takes a highly generic viewpoint by including the entire context of IS. This research places the factors in a new light by discussing their relevance to modern software engineering team capabilities. This is especially important considering the rise of software development approaches like Agile or DevOps which rely on decentralized decision-making structures and on building effective team capabilities. These insights and the resulting taxonomy may be used by researchers to conceptualize the organizational context and to conduct further research on this topic.

Furthermore, we present a contextual model including 15 factors which are particularly relevant for software engineering teams. This subset of contextual elements was created and validated with a group of practitioners who confirmed their importance and relevance. All factors are specific and analyzable which means that the model may be used by researchers and practitioners in order to gain a deeper understanding of a team's context. Similarly, the model may guide IT managers and team members in their decision which capabilities they need to build and invest in. This way, the results of this research are ultimately expected to help improve the performance of software engineering teams.

B. Limitations and future work

The results of this research are subject to a number of limitations which are inherent to the research methods employed. Firstly, the use of a focus group may be critiqued in terms of measurement bias and unclear levels of analysis [14]. While the results of focus group sessions provide analytical validity by explaining individuals' motivation and behavior, they are not intended to represent statistical validity. [14] We have taken measures as suggested by Belanger [14] to increase generalizability, internal validity and relevance of the results by carefully selecting the domain experts, clearly defining the population and unit of analysis as well as describing the process and interactions of the group session. Future research could focus on whether the same contextual factors as identified in our study are relevant to populations other than software engineering teams.

Due to the maturity of the research on context of information systems, we have chosen to conduct a tertiary study on the extant body of knowledge. The papers included in this review were selected based on the authors' judgement of their contribution towards the research question which could potentially imply a form of bias in the selection process. Furthermore, the list of 56 contextual factors included in this research should not be considered complete. Further research should focus on extending the list of factors and further validating the subset of 15 factors chosen by the focus group in an empirical setting. Additionally, more research should be conducted on technological and environmental context factors since our review suggests that only a limited number of items in these categories have been identified thus far which implies that extant literature may not cover these categories fully.

Lastly, the research at hand had the goal of investigating which factors influence software team capabilities. Further research should be conducted to investigate the nature of these relationships and thus further our understanding of how the contextual factors in fact affect the team capabilities.

VI. CONCLUSION

This paper presents the results of a tertiary study and subsequent focus group study on contextual factors affecting the capability configuration of software engineering teams necessary to increase their performance. We present a taxonomy of 56 factors pertaining to the technological, organizational and environmental context of organizations and present a contextual model including a subset of 15 factors chosen by the focus group which strongly affect the nature of software engineering team capabilities. The model can be used by researchers and practitioners to analyze the team context and may guide IT managers and team members when deciding in which capabilities they want to invest.

VII. ACKNOWLEDGMENT

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APPENDIX

TABLE IV. TECHNOLOGICAL CONTEXT FACTORS

Contextual Factor	Definition
Batch size	Whether the team processes large chunks of tasks
Degree of legacy landscape	Whether the organization uses a lot of legacy systems
Information processing load	Amount of information that is processed by the system
IS maturity	Maturity of the IT department/domain and it's systems
Relationship to other systems	Degree of connectedness to other computer-based systems vs freestanding
Requirements uncertainty	Whether the requirements for the system that the team need to work on are clear
System accessibility	Easiness to access and use the system for end-users
System relevance	Whether the system on which the team is working is important to the core production of the company
System visibility	Whether the systems on which the team is working is visible/noticeable inside or outside of the organization
Technology complexity	Complexity of technology landscape in the organization
Technology routineness	Number of exceptional cases, analyzability of problems presented by technology

TABLE V. ORGANIZATIONAL CONTEXT FACTORS

Decision-making	
Analysis of decisions	Whether decisions are taken after studying and analyzing the environment or are rather taken based on gut feeling
Decentralization	Degree to which decision-making powers are concentrated in a few leaders at the top of the organizational structure
Decision process length	Length that it usually takes to make a decision
Decision repetitiveness	Repetitiveness with which a decision is made (unique decision or not?)
Decision-maker experience & skills	Experience and skills of the decision-maker
Information uncertainty	Amount of information available based on which decisions are taken
Multiplexity	Amount of factors considered in decision-making
Planning horizon	Length of the planning horizon in which a company makes plans
Rank of decision-maker	Rank of the person which takes decisions regarding the IT project/product
Structure	
Bureaucratization	Degree to which formal rules, procedures, and channels guide actions; number of hierarchical levels degree of diffusion
Departmental interdependencies	Extent to which the departments depend on each other
Differentiation	Degree to which departments are similar or different to one another in terms of their modus operandi, time horizons, goal orientations, and the interpersonal habits of their staff.
Integration	Degree to which departments are aligned and connected through shared policies, objectives, participatory management etc.
Lateral relations	Degree to which there are organizational arrangements in which managers work primarily with other managers at similar levels in a hierarchal sense.
Organizational maturity	Maturity of the organization
Organizational size	Size of the organization
Task	
Level of self-containedness of tasks	Level to which the tasks are self-contained, e.g. product groups instead of functional specialization
Task difficulty	Difficulty of the task
Task diversity	degree to which the tasks that the team needs to fulfill are similar to each other
Task interdependence	Degree to which tasks within the team depend on each other
Task level	Level at which the team operates (operational, managerial, strategic)
Task structurability	Degree to which the problem can be analyzed by following an objective, computational procedure to resolve problems. A correct response can usually be identified
External Behaviour	
Organizational adaptiveness	Degree to which organization adapts to changes in the external environment
Proactivity	Tendency to be ahead of competitors in taking certain actions.
Pursuit of competitive advantage	Degree to which organization seeks a competitive advantage
Resource	
Available budget	Budget that is available to invest in the IT product
Level of (slack) resources	Amount of resources in general, such as employees, money, and hardware
Other	
Consciousness of strategy	Degree to which employees within the organization are aware of the strategy
Departmental responsibility ambiguity	Degree to which the responsibilities of teams/departments are clear
Encouraging orientation	Degree to which the organization promotes and encourages change and creativity among employees
Equivocality of communication	Clarity of communication vs ambiguity, the existence of multiple and conflicting interpretations about an organizational situation
Level of top-management commitment	Degree to which top-management is committed to delivering the IT product
Political turbulence/cohesive environment	Degree of change of project prioritization and selection by individuals or groups that hold the most power at the time of the decision. In such an environment, individuals will act in accordance with their personal interests rather than for the good of the community.
Project rank	Importance of the team within the organization
Promotion of the product in the company	Degree to which the product of the team is promoted in the company, e.g. through a champion
Shared domain knowledge	Degree to which different departments in the organization possess IT knowledge

TABLE VI. ENVIRONMENTAL CONTEXT FACTORS

Contextual Factor	Definition
Analysability of cause-effect relationships	When environmental relationship are clear and analyzable, managers can rely on explicit data to answer questions that arise.
Environmental complexity	Number of environmental variables and their interdependence
Environmental dynamism	Rate and pace of change in the environment of the organization
Environmental hostility	Hostility results from threatening actions of competitors (e.g. cut-throat competition) or threatening shortages of scarce resources due to strikes, governmental regulations or credit squeezes
Environmental uncertainty	Degree to which the environment is uncertain or can be predicted
Heterogeneity	Whether the environment/market is homogeneous or diverse with respect to required product-market orientations, consumer characteristics, production technologies, and raw materials markets
Industry size	Size of the industry
Level of regulation	Level of governmental regulation in the industry
Organizational intrusiveness	Extent to which organizations actively intrude into the environment. Some organizations actively search the environment for an answer. They allocate resources to search activities. This may also include testing or manipulating the environment. Passive organizations accept whatever information the environment gives them.