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The mission of the IJISPM - International Journal of Information Systems and Project Management - is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

The IJISPM publishes leading scholarly and practical research articles that aim to advance the information systems management and project management fields of knowledge, featuring state-of-the-art research, theories, approaches, methodologies, techniques, and applications.

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Correspondence and questions

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Editorial

The mission of the *IJISPM - International Journal of Information Systems and Project Management* is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

It is our great pleasure to bring you the third number of the ninth volume of IJISPM. In this issue readers will find important contributions on agile methods, project teams, and digital transformation.

The first article, "Bringing templates to life: overcoming obstacles to the organizational implementation of Agile methods", is a viewpoint authored by Michael Durbin and Fred Niederman. Agile software development methods have become accepted as a template for organizations to create new products. Though generally viewed as an aid to productivity, there are a number of barriers to experiencing their full benefit. One such barrier pertains to the implementation of agile methods across the range of organizational levels from the use of tools to culture, norms, and policies creating the context within which projects are performed. This viewpoint article examines in detail the experiences of one expert at integrating agile technique, approach, and philosophy into the broader organizational setting. Numerous particular lessons and prescriptions result from this discussion. Turning around the grounded theory approach where numerous individuals are interrogated mildly in regard to a particular phenomenon, the discussion surfaced in this article results from repeated interviews with one domain expert. Lessons and comments are organized into four sections: individual team member, organization, transitioning, and tools and techniques.

The title of the second article is "In whom do we trust? Critical success factors impacting intercultural communication in multicultural project teams", which is authored by Wenyuan Yu, Kathryn Cormican, Qiong Wu, and Suzana Sampaio. Trust is a significant enabler for intercultural communication in project teams. Researchers and practitioners, therefore, need to know which factors might enhance trust in intercultural communication. Contributing to the yet limited number of studies in the field of intercultural communication for multicultural project teams, this research theoretically analyzes and empirically investigates the enablers of trust for intercultural communication focusing on emotional intelligence, empathy, interaction, and transparency. Using a field sample of 117 experienced project managers working in multicultural project teams, the authors find that interaction and transparency significantly and positively influence trust in intercultural communication; empathy marginally and positively influences trust. Emotional intelligence does not exert an effect on it. These results provide novel theoretical and empirical insights which have practical implications for project managers. The findings direct suggestions for additional theoretical work.

The third article, authored by Liliana Machuca-Villegas, Gloria P. Gasca-Hurtado, and Mirna Muñoz, is entitled "Measures related to social and human factors that influence productivity in software development teams". Software companies need to measure their productivity. Measures are useful indicators to evaluate processes, projects, products, and people who are part of software development teams. The results of these measurements are used to make decisions, manage projects, and improve software development and project management processes. The research is based on selecting a set of measures related to social and human factors (SHF) that influence productivity in software development teams and therefore in project management. The research was performed in three steps. In the first step, there was performed a tertiary literature review aimed to identify measures related to productivity. Then, the identified measures were submitted for its evaluation to project management experts and finally, the measures selected by the experts were mapped to the SHF. A set of 13 measures was identified and defined as a key input for designing improvement strategies. The measures have been compared to SHF to evaluate the development team's performance from a more human context and to establish indicators in productivity improvement strategies of software projects. Although the number of productivity measures related to SHF is limited, it was possible to identify the measures used in both traditional and agile contexts.

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"An attempt to understand complexity in a government digital transformation project" is the fourth article and is authored by Kristin H. J. Hafseld, Bassam Hussein, and Antoine B. Rauzy. Digital transformation projects will become one of the dominating tools for mastering digital transformation in governments. Studies show that such projects are complex undertakings and increasingly difficult to manage. The purpose of the paper is to provide a better understanding of the factors that cause complexity in government digital transformation projects. The authors use an in-depth case study approach to investigate factors of complexity in an ongoing digital transformation project. The results indicate that complexity in this project is rooted in dynamic relationships between multiple dimensions of organization, technologies, and innovation. The authors conclude that when organizational structuring, the introduction of new technology, and efforts to innovate and create added value for citizens and businesses operate in tandem, the pervasive complexity associated with delivering government digital transformation projects becomes increasingly difficult to manage.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

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João Varajão is currently a professor of information systems and project management at the *University of Minho*. He is also a researcher at the *ALGORITMI Research Center* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997), and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are related to Information Systems and Information Systems Project Management success. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 100 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served on numerous committees of international conferences and workshops. He is the co-founder of CENTERIS – Conference on ENTERprise Information Systems and ProjMAN – International Conference on Project MANagement.

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Bringing templates to life: overcoming obstacles to the organizational implementation of Agile methods

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Bringing templates to life: overcoming obstacles to the organizational implementation of Agile methods

Viewpoint

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Abstract:
Agile software development methods have become accepted as a template for organizations to create new products. Though generally viewed as an aid to productivity, there are a number of barriers to experiencing their full benefit. One such barrier pertains to the implementation of agile methods across the range of organizational levels from the use of tools to culture, norms, and policies creating the context within which projects are performed. This essay examines in detail the experiences of one expert at integrating agile technique, approach, and philosophy into the broader organizational setting. Numerous particular lessons and prescriptions result from this discussion. Turning around the grounded theory approach where numerous individuals are interrogated mildly in regard to a particular phenomenon, the discussion surfaced in this paper results from repeated interviews with one domain expert. Lessons and comments are organized into four sections: individual team member, organization, transitioning, and tools and techniques.

Keywords:
agile methods; software development; project management; portfolio management; agile mindset; SAFe.

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1. Introduction

Many organizations have moved from solely using a traditional plan-based to either a mix of plan-based and agile approaches or solely to agile. As Birkinshaw [1] states: "Most Information Technology (IT) departments in large companies today are adopting agile techniques to some extent, although with varying degrees of success (p. 39)". At the level of individual projects, it is widely held that agile methods provide net benefits relative to traditional Systems Development Life Cycle (SDLC) plan-based methods, and some evidence points to this (e.g., Lee and Xia [2]). However, converting the possibility of benefit from management of individual projects to fully realizing them may require more than shifting the practices of individual projects. However, for firms moving from a traditional to an agile organizational approach to IT projects, the transition is often difficult. As Hobbs and Petit [3] state:

> *"During preliminary interviews prior to undertaking this research, the authors discovered several large organizations that had been experimenting with agile methods over a period of five years or more and that these organizations are struggling to scale from a few agile teams to an organization-wide implementation of agile methods (p. 3)."*

Where numerous templates exist, such as SAFe, for describing how agile methods at the project level may be integrated within organizational systems (technical and non-technical), the actual implementation and institutionalized is often not fully realized. The purpose of this discussion is to provide insights into the problems and potential solutions to shifting toward greater use of agile and acquisition of its benefits.

The writing of this viewpoint paper has been an educational process for both authors. During our investigation, an emerging theme running through the bulk of the transition-related problems and issues pertains to "agile mindset". We will refer to this in regard to many of the specific observations and recommendations below. What we mean by this is an understanding and commitment at a deep level to the practices of agile methods, even when they seem unusual or non-intuitive, not only in the broad stroke but in the everyday details. This is a mindset that may come naturally to some people who see agile as an exciting alternative to traditional approaches from their first introduction, but, as it happens, such an attitudinal shift is certainly not universal and can impinge on many ways in the shift from a traditional to agile project management organization. We use the term "mindset" following Imran and Gregor [4] as they conceptualize "IT mindset" as referring to a set of cognitive filters, the product of an individual's history developed through an iterative process that guides the interpretation of new information[1]. In this sense, the cognitive filters of one imbued in the traditional methodologies would vary from those of one committed to and comfortable with the agile approach. It is our contention that while difficult to measure, even to observe, the shift from the traditional to an agile mindset from top to bottom among those involved in implementing agile projects is critical. In some ways, our findings are the inverse of those of Conboy [5], who found that some highly touted agile practices like customer inclusion on the project team and standup meetings were not effective. On the other hand, this might be interpreted to reinforce how important it is to invoke sincere application of agile "mindset" even in agile techniques.

Every organization moving from an SDLC traditional approach to an agile one confronts challenges effectuating a successful conversion or transition Conboy [5]. Particularly for organizations strongly steeped in traditional development approaches, initiating, managing, and solidifying such transition is critical to extracting value[2] from the application of agile methods. Dingsøyr [6], for example, presents a set of 10 lessons in five categories that roughly align with the lessons we present in this paper. Where our lessons overlap, we attempt to present further detail and a broader range of managerial responses. Our discussion is organized in four categories – individual adoption, organizational adoption, transition, and tools and techniques, which enhances the set of questions raised for future research in Niederman et al. [7, p. 7]. Note we do not claim these observed principles to be the only ones that may be effective, nor

[1] This is one of a number of references to "mindset" as defined by Imran and Gregor [4], but we feel this one comes closest to describing how we use the term in this paper.

[2] We use the term "value" in the sense of enabling new user capabilities or reducing process complexity and the like, rather than a dollar value of finished components, as one would with earned value management programs.

that they will work in all circumstances. Rather we present them as a sort of "proof of concept" that they have worked (or have not worked) in at least one set of experiences and should be worthy of consideration for those confronted with similar issues and circumstances.

This essay is based on a practitioner-academic dialogue. It highlights the experiences and lessons learned by a particular highly successful project and portfolio manager who has assisted with the transition from traditional to agile development methods settling on a particular sort of hybrid approach[3]. This approach addresses project management concerns that are not addressed directly by approaches to agile (or SDLC) per se. It also acknowledges the likely benefits in some situations of shifting SDLC-oriented teams gradually toward agile methods by adding agile tactics such as standup meetings and Kanban activity lists as the team members become open to assimilating them.

The practitioner (first author) has 30 years of experience managing projects, portfolios and now introducing agile techniques to organizational project management orientation. The academic (second author) has studied the literature on traditional and agile methods, co-edited a special issue of Project Management Journal on moving agile technique from software development to other task areas, and taught systems analysis and design as well as project management to graduate and undergraduate students for two decades. As a result, the observations are based on the practitioner's experiences filtered and extended by acquaintance with the academic literature. The goal is to bring this heuristic knowledge into a more formal setting for generalization and gathering support (or refutation) for these practices and observations.

On the surface, our research method can be viewed as reversing some of the tendencies of grounded theory. Where grounded theory compresses detailed observations into more general themes using successive rounds of coding to create broad theory by proposing how such themes are related, the approach of this study focuses on the detailed observations themselves, probing more deeply into their specifics and what they might mean for others. Where grounded theory, typically, interviews a range of individuals one time across a range of subjects to get overall views on topics of interest, this approach used multiple iterations of interviews to look in increasing detail at the issues raised. This approach mimics the agile method of iterations for developing artifacts (in this case lessons), observing and filling gaps between them, and examining not only the "what" leads to more conversion success but also the "how" and "why" such lessons have worked and are advocated for consideration.

One recent trend in IT project management is toward developing "hybrids" that combine elements of traditional and agile methods. This may be a temporary phenomenon as organizations add agile methods and remove traditional ones in the process of evolving toward agile, or it may be a more static approach to creating a new form that combines the best of both or appeases staff members with multiple philosophies. We do not focus on these hybrids per se but rather are proposing a sort of hybrid not between traditional and agile methods but by surrounding relatively pure agile methods with explicit project management techniques. Difficulties adopting pure agile "straight out of the gate" are documented by Baskerville et al. [8], which traces changes from traditional to agile approaches in particular organizational settings. That organizations adjust the "pure" practice of agile is well known, but the shape of such hybrids after adjustment and what is needed to substitute them for well-established practice is not as well examined.

It is worth noting that many of the issues and concerns of this viewpoint are less pressing and even non-existent in "greenfield" start-ups, whether new organizations or new IT departments, where the traditional practice is not ingrained and, therefore, need not be removed. On the other hand, the impression that agile practices in the full or hybrid form are universally implemented is belied by the observation of organizations currently beginning transformation and others remaining in a limbo of claiming to use agile but still clinging to traditional practices.

[3] Tripp et al. [18] describes a variety of components from both traditional and agile approaches considering, among other things, how these are combined in various configurations.

Some of the models referenced in this paper are fairly standard "off the shelf" frameworks available on the web or in agile process books. We will generally not reiterate what these helpful models have provided, but rather it is our goal to point out ones that have been particularly useful and elaborate on nuance regarding how to put them into practice. It should also be noted that much of our findings are consistent with the long research experience described in Conboy and Carroll [9]. For example, among their major challenges are issues of ensuring a common vocabulary (#1 in their scheme), issues of organization structure (#4), of top-down versus bottom-up implementation (#5), and misalignment of customer processes and large scale frameworks. All of these challenges are observed in our discussions. We aim to provide examples of these and some, hopefully, useful approaches to addressing them in this study.

Below we discuss fundamental detail level issues grouped by individual adoption and adaptation, organizational leadership and structure, transitioning tactics, and tools and techniques. No claim is made that these are either the only or the best way to group these lessons and observations. Nor that there is no overlap and commonality among these lessons, particularly as regards the pervasive yet moderately differentiated need for a changed "mindset" to make agile work well. Following agile approaches requires the spirit of agile as well as the mechanics of following its "rules".

2. Individual adoption and adaptation

Individuals work as part of teams with varying levels of collaboration and interdependence, but at the same time teams do not come to life without individual members. The individual is enabled and constrained by the organization, while the organization can accomplish nothing unless individuals complete their assigned and ad hoc tasks. The following specific issues and lessons can be more easily identifiable in terms of individuals as they work in teams. These can be divided into adoption issues regarding characteristics of individuals engaging in agile development and adaptation issues referring to procedures, interactions, and effects encompassing tendencies of whole projects.

2.1 Adoption

Self Discipline and Collaboration. Typically, agile approaches require shifting to a different type of work style by team members. Some who are accustomed to traditional approaches have not the experience, imagination, or habits to begin asserting initiative and taking responsibility for completion, that a fully realized agile approach requires of all team members. It is also important to look for situations where team members feel "forced" to shift to agile approaches. In some cases, shifting these folks back to teams using traditional methods works best; in cases where there are no traditional method teams to be shifted to, team members may resign or look for work elsewhere.

> *Managerial approaches* include: careful selection of team members with a preference for responsibility-taking and incentives/reinforcement for taking the initiative – note that this might require allowing more range for diverse approaches and room for some failure (with opportunities for correction and improvement). Acceptance, even eagerness to move to agile approaches tends to correlate with the traits of a higher level of comfort with communication. Managers are advised to look for and cultivate this characteristic in structuring a high communication culture.

Agile leadership experience. Successfully leading projects using agile technique is aided by experience. This shows up in terms of confidence in making key choices, determining which issues are normal and which need special handling, and the like. Experienced leaders may not be available for all (or any) projects, particularly at the start of a new program or shifting from traditional to agile.

> *Managerial approaches* include: bringing in outside coaches, providing some slack on schedule and cost targets when supervising less experienced leaders, and training programs for new project managers. Certifications for scrum masters and the like can help impart skills and create a common language and approach.

Developing judgment and self-governance. In traditional project teams, much responsibility is embedded in individual roles. The database specialist makes sure tables are set up properly, and the network specialist makes sure that communications among components are reliable. However, in agile teams, responsibility devolves to the entire

team. Individuals may have a specialty but are expected to function in multiple ways exhibiting what is often referred to as "T-shaped skills". In a well-functioning team, people expressing conflicting views and take action to resolve their conflicts. In ill-functioning groups, people tend to walk away from these responsibilities. When the committed work is not finished at the end of a sprint due to team members not accepting this responsibility, there is a temptation for the scrum master or project manager to step in and resume assigning responsibility. However, this can become a habit, and the team may learn that it can avoid having to accept such responsibility.

Many leaders and team members embrace the freedom and responsibilities that come with the transition to agile and its tendency toward self-governing teams. However, not all key personnel are likely to embrace this to the same degree, particularly when they come to see the drudgery as well as influential aspects of administration. Those who do embrace the idea of self-governance may still need to develop abilities to exercise freedom wisely and to add clarity to communications to collaborate with other team members. Those who do not embrace such freedom and responsibility may also need to learn how to exercise higher levels of personal responsibility, whether this is their preference or not.

> *Managerial approaches* include: assessing formally or informally the capabilities of each team member; modeling excellence in their own freedom tempered by responsibility and task completion; and generously working with team members when their skills need improvement or attitudes need reevaluation.

Semantics. It is important to establish common meaning to common terms. Team members and other stakeholders can get really confused when using terminology differently. Rather than adopt common meanings, individuals may use alternative meanings to fit narratives that take away from rather than contribute to the overall mission. For example, it is important when using Jira [20] to understand the names of levels like epic, user story, and the rest.

> *Managerial approaches* include: Listen carefully to what is meant as well as what is said when interacting with team members and other stakeholders. Be quick to react when terminology begins to slip from the defined usages. Note that observing such a divergence of meaning can be a useful opportunity for insight into deeper problems that the team needs to have addressed.

2.2 Adaptation

Breaking down the work into manageable user stories. Use cases are more associated with traditional than agile methods. A use case describes how a system will act. In agile a user story is about the result and benefit of the story being described. User stories leave out details for the agile team to explore. When developers are solely using agile methods, typically they will only focus on user stories. Hybrid methods will sometimes extend the range of methods to identify end results to include information requirements, and use cases along with user stories. User stories differ from information requirements in their central concern for creating ultimate value for users (including sponsors and those affected by rather than directly using systems). As a result, the emphasis shifts from detailed enumeration of all features in the new system to creating particular results with mechanisms only generally specified. It is a shift of attention from means to ends. Team members immersed in traditional information requirements development tend to experience discomfort with the "loose ends" of not detailing all specifications before starting the building process. Note that this is an area where team member concerns may be inflamed by management demands, as will be discussed below. This is one area where "greenfield" teams are more likely to move directly into a focus on creating value as quickly and efficiently as possible. More specific issues for agile teams relative to user stories include; integrating stories of multiple users and tasks that are likely addressed by single or related applications; ensuring that all steps are included; disaggregating continuous user actions into discrete value-adding tasks; and focusing on translating physical processes into digitally managed or enacted ones.

> *Managerial approaches* include: establishing a continued and consistent focus on value creation throughout the development process supporting the agile mindset.

Responding to setbacks. If a project "goes south", perhaps it only makes sense to return to familiar procedures before more or irreversible damage is done. On the other hand, there are likely times when it is only by pressing ahead that temporary setbacks are overcome and where momentum is gained for more permanent change. Even at some cost,

moving through setbacks and staying the course can provide important lessons that inform long-term future actions. For example, shifting to written approaches to tracking issues and exceptions may temporarily slow down product development progress, but as it becomes routine may accelerate task completion and smooth task assignments. Knowing when to move forward anyway and when to draw back is pivotal.

> *Managerial approaches* require developing a sensitivity to the effects going forward or backing off will have on the team. Will going forward ultimately pay off, even if not obviously so in the short run? When is it better to capitulate in the short term in order to return to the issues and, having gained insight into the resistance, approaching it in, hopefully, more effective ways?

Lines of authority. As in all projects, it is difficult to motivate team members to perform all tasks at a high level of quality when their reporting is to their own functional area manager rather than the project manager. At one client site, it was almost impossible to hold members of the agile team accountable, including their boss who was the product owner. The project team resisted accountability unless it came directly from their functional manager. One of them actually told the project manager that it was not his responsibility, even if it was his responsibility. Clearly, this is a problem not unique to agile project work, but the agile approach is not immune from it. Managers, to our knowledge, have no automatic or foolproof ways to address this sort of problem.

> *Managerial approaches* include: working to fundamentally alter how organizations structure their lines of reporting; use informal levers such as culture and peer pressure when available; though perhaps unfair at times, shift work to more responsible employees; attempt to align incentives with productive engagement where possible; and elevate the problems to unitary managers where they may be addressed. It can also be helpful for managers to establish the "rules of the road" early, which involves standards for social interaction and behavior such as when and how to escalate issues and standards for naming items, storing in common directories, and version controls from initiation to having fully tested components. All of these approaches have the potential to backfire and make matters worse but are worth considering and customizing for individual circumstances.

2.3 Summary

Table 1 summarizes the individual and team adoption and adaptation factors.

Table 1. Individual and team adoption and adaptation factors.

Factor	Description
Adoption	
Self-discipline and collaboration	Team member selection, "weaning" from traditional motivators.
Agile leadership experience	Acquiring and using experience and expertise. This can create a paradox starting out with agile because inexperienced leaders may run into serious difficulties blamed on the method rather than viewed as just a natural part of the learning curve.
Developing judgment and self-governance	Need to appreciate that agile requires more "art" skills than traditional development beyond the "science" of technical skills.
Semantics	Determine a meaning for each key term, use these consistently, and insist on the same from all team members.
Adaptation	
Breaking work down into manageable user stories	Build competencies in the art of disaggregating epics into user stories based on units of value delivery and developer activities.
Responding to setbacks	Both the SDLC and agile are complex systems where various activities are intertwined. One task may be more complex in agile, but doing it in an agile way may make downstream tasks more effective. A quick reaction to the initial difficulties of an upstream task being more cumbersome may restrict the downstream ability to capitalize on new procedures.
Lines of authority	Establish, where possible, informal levers for asserting authority and ensuring completion of activities where formal ones are missing or not organizationally supported. A good project manager can surface and manage conflict among group members, whether in terms of details of a task, assignments, or understanding of various instructions. Without a designated project manager, alternative tactics for such conflict resolution must be established, or such conflict can fester and slow project completion.

3. Organizational leadership and structural factors

As individuals and teams work within the organizational umbrella, organizations are composed of individuals and groups. We can look at organizational activity through either lens, but at the end of the day they are intertwined. We have divided consideration of the organizational factors into leadership and structure. Leadership pertains mainly to attitudes and skills of senior leaders generally outside, but responsible for, the performance of the development teams. Structure refers to how the operations of projects and teams are organized.

3.1 Leadership

Top Management Support. The ability of agile to take root and flourish is inhibited if senior leaders set policy and act upon the mindset of task performance rather than value delivery. Senior leaders tend to have risen through the ranks understanding traditional methods and frequently are uncomfortable without the reporting and signs of progress that attend traditional projects. It can be disturbing to agile team members to be asked to shift to value delivery when senior managers continue demanding task performance reports. Much of the value of the agile approach derives from focused concern on delivering value in the customers' workspace and treating tasks fluidly as mechanisms to create such value, adding and discarding them as new ideas emerge. This adds a measure of unpredictability that is difficult to capture in traditional reports and depends on the understanding and initiative of team members to effectuate.

> *Managerial approaches* include: It is not location, location, location, like with real estate rather, it is value, value, value. It is not just training but establishing a commitment to agile and an agile mindset that pushes the method from abstraction to realization.

Cadence. Project cadence refers to the pacing and flow of the project as it is carried out. Agile methods, of course, differ from SDLC by emphasizing iteration rather than progression sequentially through stages. There is a temptation to think of each iteration as a "mini-SDLC" where a module in the larger application can be worked through from requirements, through coding and testing, to implementation. Such a way of thinking may be helpful in breaking up a large project into smaller well-known pieces, but misses to a large extent the exploratory value-seeking aspect of the agile process. The leadership of the larger organization through that of each project needs to focus on the alternative rhythm of embedding the creativity of the project into the understandings being derived from the partially completed new states and what they suggest for the ultimate product. This is not to say that there should not be steady progress toward overall goals, but it is to say that such progress may not be accrued in one steady predictable line.

> *Managerial approaches* include: it is important to realize that Scrum is both iterative and incremental. Each iteration is focused on delivering incremental value; in some cases, items embodying new value are moved to users in batches as completed at the end of iterations, even though the value is planned to be created throughout the process. The critical awareness is that agile processes deliver value regularly, but the exact specification of that value is not precisely definable at the beginning of the project.

Insulating. A major purpose of hybrid approaches derives from the different mindsets of the agile team (once fully established) and more traditional senior managers. The move to agile shifts a team from structured sequences in development, to accumulation of knowledge and partial product with the intention of creating maximum value (rather than completing the plan). However, traditional managers are not necessarily comfortable allocating money and effort with only a vague idea of the value to be created rather than seeing the detailed elements of the product. It is worth pointing out that many of the commonly practiced project management tasks such as risk analysis, change management, or issue tracking are explicitly part of the SLDC, which is focused on the steps in producing new artifacts rather than managing the process per se.

With the switch from SDLC to agile, however, the unspecified nature of such project management activities becomes apparent, and project, program, and portfolio managers have the opportunity to translate broad agile work team goals into the sort of reporting that will allow senior managers to have insights into the current state of projects as they mature. This buffering activity is more of an art than a science and requires ongoing adjustment so that formal plans and actions on the ground can be steadily realigned as they co-evolve.

> *Managerial approaches* include: insulating the team so it can do its scrum activities, but PM translates the JIRA metrics into something that senior managers are accustomed to seeing.

3.2 Structure

Bringing Work to the Team. Organizations moving to agile require a shift from a mindset of moving teams to the work to work to the team. In general, agile teams should remain intact from project to project, receiving new assignments rather than having teams built afresh for each new task as it is moved to being a project. When teams stay together this way, they can build knowledge as well as work procedures instead of reinventing it whenever the team is abandoned. DevOps, in principle, incorporates this even further by leaving the team building a new application intact to maintain what it builds. This has the added advantage of teams being incentivized to build concerns for ease of maintenance into the design and building of new systems – a practice that may add some time and cost to projects but the payoff in their lifetime with faster and more reliable updating.

> *Managerial approaches* include: forming teams that stay together or bringing the work to the team so that the team can specialize in particular categories of projects rather than forming new teams for each project. The purpose, of course, is both to develop strong team dynamics and expertise in more focused business areas. Constant flow of projects, customers get to know the team members, more domain knowledge; like a baseball team, same team together through the whole season.

Cross-functional integration. The product manager plays a key role in the agile development team. Sometimes known as the "customer representative", the role may demand multiple, even contradictory, actions and positions by those fulfilling it [10]. However, some projects call for products and services that cross boundaries within the organization (or across multiple customer segments). When there is a product manager, but the product is aimed at supporting multiple processes, departments, or divisions, it is important to account for the effects of the product across user groups. Obvious solutions, but not necessarily ideal long-term solutions, are to add all features requested by any group. This may provide a product that serves many user stories but may generate bloated, inefficient products based on weak architecture. The product manager may not be able to represent all the various outside stakeholders and, even if cognizant of all the diverse requirements, may not be able to blend them into a single lean set. As a result, skills needed for this position include the ability to elicit needed and wanted features; to differentiate among these and prioritize them, to find solutions that may differentiate features for users while providing integrated and streamlined "plumbing", and, perhaps most importantly, the ability to explain and persuade clients when requests cannot be met while retaining the integrity of the system (or at least not at the prices they are willing to pay).

> *Managerial approaches* include: maintaining awareness of the varied uses that different groups in the organization will make of the final products, begin early to develop tactics for meeting as many needs as possible, providing, where possible, common architecture for meeting multiple goals and communicating about tradeoffs that seem to be inevitable.

Scaling. Techniques such as Kanban [21] and Scrum [15] can work very effectively in small groups but become difficult to manage as the size of the project and team grows. Kanban lists can grow and become overwhelming to navigate. Scope changes with the addition of project tasks can cripple the ability to come to completion unless user story prioritization and screening are accomplished by the product owner. Scrum meetings with more than 10 participants can start to leave out important messages, take a burdensome long duration, or proceed so quickly that not all are adequately informed about all critical items.

It is critical to use the support of software tools such as Jira to administer a more complex and higher quantity of tasks. It may be important to divide teams up into separate scrums and/or to perform them through collaboration software like Zoom [22] to provide multiple channels such as dialogue and chat as well as to automate the recording of proceedings and ease the capture of minutes for the permanent record.

> *Managerial approaches* include: Conducting a "scrum of scrums". By engaging the scrum masters in debriefing together, brings disparate pieces together toward integration. Release plans and calendars can be distributed so all scrum masters and team members know what deadlines are being worked toward as well as integrating standards so that naming conventions, interfaces, and the like, which may tend to stray, are brought back into conformity.

Product delivery. It generally does not help to speed up an assembly line if there are no trucks available to deliver the products. Agile methods ideally produce products more quickly but organizational institutions are needed to move them to actual use. One model for this is the SAFe model [19] that displays the relationship of agile project methods to an array of allied organizational programs for smoothly moving new applications into production. Another model is DevOps [23], where the transition from development to operations becomes a focus of process actions. Hemon et al. [11] describe a case showing the transition from agile development to a DevOps delivery program.

> *Managerial approaches* include: realize that models like SAFe are relatively easy to conceptualize but more difficult to actualize. That said, these sorts of models provide a useful template or outline of needed structures into which individual projects, clustered programs, or portfolios can be embedded. Build capabilities for the transition of products from development into operations.

Method selection. There is a benefit on a project-by-project basis for optimizing choice between SDLC and agile approaches for each project. The Stacey Matrix (e.g., Agrawalla [12], see also Stacey [13, 14]) for a broader discussion of the underlying conceptualization) provides one approach to assessing which to use based on the clarity/obscurity of the requirements and the familiarity with the technology. In essence, projects where dimensions are well known, can be handled routinely with SDLC, but as they grow in complexity, the value of agile emerges.

> *Managerial approaches* include: Set up a process that assigns projects to traditional or agile approach teams. Maintain a backlog of projects for both and refrain from shifting projects to less optimal selections just because this set of teams has available capacity. Over time, calculate the ratio of traditional and agile projects and align the size of team members to more or less the same ratio.

Administering Multiple Approaches. In order to accommodate both traditional and agile approaches fully in the organization, either all staff need to be familiar and comfortable with both, or staff members need to be grouped and assigned to those projects adopting the techniques for which they are skilled. Either approach necessitates some management overhead and effort. Costs, therefore, of managing multiple development styles should be balanced against the rewards of more optimal project matching.

> *Managerial approaches* include: The ratio of traditional to agile should be a function of the number of complex and innovative projects versus those that are routine and more predictable. Assuming discrete structures for traditional and agile portfolio management, the organization will want to install an efficient method for sorting the right project to the right team, staff the pool of team members for each group approximately according to the expected ratio of each, provide cross-training for all team members so that, when necessary, for example, if the ratio changes, staff members can shift between the two project structuring approaches.

3.3 Summary

Table 2 summarizes the organizational factors leadership and structure.

Table 2. Organizational factors leadership and structure.

Factor	Description
Leadership	
Top Management Support	Senior managers must transition from a task orientation to a value creation orientation and develop new ways to understand interim steps toward creating value rather than task accomplishment.
Cadence	The project manager buffers the agile team from the paradox of applying creativity while being asked for detailed plays while also providing ongoing project reporting for senior management sponsors.
Insulating	Project, program, and portfolio managers have to assume the role of translator or buffer between what actions teams are taking to create value and the information senior managers need to understand current states during project execution.
Structure	
Bring work to the team	Leaving teams intact builds human capital that can be applied to enhance downstream projects.
Cross-functional integration	The product manager needs to manage demands and requests across the range of user stakeholders.
Scaling	For large projects, scaling requires more adjustment than simply breaking larger units into smaller ones or just adding more tasks and people than a process is envisioned to accommodate
Product delivery	Agile methods can ideally produce products more quickly, but organizational institutions like continual delivery programs are needed to move them from the development arena to actual use.
Method selection	Use the STACEY model or an equivalent to move lower uncertainty projects toward traditional methods and higher uncertainty projects toward agile methods
Administering multiple approaches	In order to realize the benefits of using the more appropriate method for each project, organizations may need to maintain capabilities for both traditional and agile approach teams. Achieving such benefits requires more than a skillful assignment of projects to approaches but also skillful recruiting, retention, and training for team members, skillful adjustment of incentives for team members using each approach, and effective communication among divisions to optimize the use of resources, human and digital.

4. Managing the transition

Some issues relate more clearly to transitioning to agile methods without being specific to individuals, teams, or the whole organization. During the transition from SDLC to agile, there is the need to simultaneously work at the most elemental levels of work implementation and the highest levels of policy and senior management strategy. The theme of the transition is moving policies and practices across the range of participants in a manner that keeps them in alignment and/or returns them to alignment when gaps appear.

Suppressing the old ways. New ideas need to be introduced and demonstrated repeatedly. It should not be misinterpreted that this can be a "one and done". New practices need to be reinforced, and successes need to be noted. Persuasive communication with team members needs to be consistent in the rewarding movement to the new agile terminology and procedures and moving away from the traditional. By not translating or dropping the vocabulary of SDLC, the benefits of shifting to a completely different system are not fully realized. As a result, some of the old procedures are unnecessarily retained, or new procedures are not fully enacted. While practicing the new techniques, teams may not be generating information that would have been normally produced and passed along in traditional development projects. Senior leaders in the organization can express support for moving to agile methods but retain an expectation of receiving status reports and deliverables in the same manner as when using traditional methods. This can happen even when equivalent information is reported but in an unusual format or with broader ranges of precision.

> *Managerial approaches* may include: serving as a buffer to produce data from agile projects that approximate the sort of data traditional projects automatically produce; interacting with senior leaders both to forward what information exists and to assure progress, even if produced through processes less focused on technical milestones. The project manager may need to work with both external stakeholders and internal project team members to implement the transition to some degree in parallel so that neither group gets too far outside the expectations of the other.

Managing the baseline. In traditional approaches, the baseline generally represents an absolute that should not change other than through approved change management processes. Agile team members need to view this as a starting point that will continue to evolve. The agile team may retain the original baseline to see from where they have come, but it is not used as a target to achieve. Change shifts from something to be avoided to something accepted and expected. Using the baseline in the agile method often begins with a slender set of tasks and fuzzy ideas of the finished product. As the tasks become known and the finished product takes form, the evolving baseline reflects this growth. Management of what might be added and taken away from the baseline becomes a new process management task that may require new approaches relative to traditional change management.

> *Managerial approaches* include: establishing a continued and consistent focus on presenting products that provide customer value throughout the development process even if the exact nature of the products is not fully described in the original baseline.

Shift to new tools. There is a tendency, particularly where projects have relied on standard Office tools (e.g., Word, PowerPoint, and/or Excel) to have the reluctance to use more specialized and powerful tools like Jira. Rather than implement Kanban, for example, in Excel, a transition and descent down the learning curve for more powerful tools is advised. These new tools are designed for supporting agile processes and offer additional features that, once adopted, help shape agile development work practices. Adoption of new work practices can stimulate and sometimes require advanced tool use. Movement to full use of these tools can be gradual, starting with activities that mirror those of traditional processes to the addition of new work practices along with support from new tools.

> *Managerial approaches* include: investing in powerful new tools, ensuring that team members learn effective tool use skills, and monitor that tool use occurs (correcting if and when bad habits form).

Agile coaching. The pure agile method offers a powerful template for development projects, but in organizations, it needs to be customized to account for team member preferences and personalities; senior management requirements; and the particulars of the business task environment. Agile coaches can be helpful in translating the general ideas of agile development process for the needs of the individual firm. Where qualified and motivated consulting is available from outside the organization, there is an opportunity to profit from experience across a range of industries, work products, team structures and personalities, and senior management goals and preferences. Sometimes an outside voice can bring a different voice of authority to both team members and external stakeholders that helps facilitate a willingness to experiment with new approaches.

> *Managerial approaches* include: squeezing as much value as possible from general agile techniques, looking for coaches with the sort of experience that will help customize general agile templates for local conditions, and define the role that consultants are expected to play and monitor that their advice and support is effective.

Top-down roll out. Only very small organizations can implement Agile piecemeal depending on the needs of individual projects. Very large organizations need to start with Enterprise Agile and then work it down to the project level. This is because organizations are generally structured in silos, and agile is essentially outside silos. This tends to upset organizational structures and traditions, particularly regarding incentives. For example, the number of people reporting or how their people perform on projects. Organizational structure works against you setting up agile unless these are also changed.

> *Managerial approaches* include: 1) understanding limits on implementation of agile at the work level if not supported through structure at the senior level; 2) manage up in terms of providing what's necessary for them while performing the work differently (acting as a buffer); and 3) advocating as possible for shifting senior management mindset and practices in a way that supports transformation. As people go agile, they are moving from a project approach to a product approach; instead of funding the work, they are funding the final product. In SAFe, there are three levels of Kanban, and at each level, there are limits to the number of projects handled at one time. Managing the backlog at each of these levels is critical, particularly prioritizing the sequencing of activities so that in each period, the team is working on the user stories promising the most value. In principle, this is fairly standard work, but in practice, the key is the rigor with which it is implemented.

4.3 Summary

Table 3 summarizes the transition requirements.

Table 3. Transition requirements.

Factor	Description
Suppress old ways	Managers need to bring external stakeholders and team members long at roughly the same pace to maintain mutual understanding and alignment.
Managing the "baseline"	The use of the baseline needs to be shifted from a target that team members put effort into meeting to a documentation of the evolution of a project as the team focuses on creating end-user value.
Shift to new tools	It is important to align the shift to new tools reflecting changing work practices in order to facilitate and reinforce both.
Agile Coaching	When carefully selected and skillfully monitored, outside consultants can bring new ideas and help reinforce essential new practices.
Top-down roll out	A significant amount of top management support and understanding is necessary for the roll out of agile project approaches in large organizations.

5. Tools and techniques

Of course, tools and techniques are used by individuals or teams and endorsed and supported by organizations. Nevertheless, it is worth focusing attention on these particular tools and techniques as the choice to acquire, use, master, and extend them provides a level of structure that may persist as individuals come and go over the years.

5.1 Tools

Chargeback versus overhead. Paying project by project will inhibit adoption rather than accelerate it. Some companies push back on licensing specialized agile software per user (even when software may be as low cost as $10-20 per user). Assessing the value of using tools in increasing productivity across projects is important relative to how and from what budget they are paid for.

> *Managerial approaches* include: using the best tools available should be viewed as an investment that can be spread over many projects. Just as a farmer would prefer not to use a manual plow or an obsolete tractor and expect maximum crop yield, senior managers should not expect optimal development team performance with staff constrained to use awkward tools prone to errors or difficult functioning.

Full Use of Tools. Clients of the first author have tried to use JIRA and Scrum without the full understanding of backlogs and running the sprints. The mechanics of adding data through JIRA to Kanban lists is straightforward but can be ineffective if there are not procedures to evaluate and prioritize these additions. Individual team members are not the ideal ones to be scanning long lists of needed actions and deciding which are of the highest priority. It is not sufficient to just walk activities through Kanban, even though that technique can work, for example, where an IT dept handles problem tickets. However, for this to work in agile teams, there needs to be more information. There is no inherent accountability in Kanban in and of itself. It requires the explicit accountability of Scrum to make it work. Kanban by itself only gives the appearance of agile but does not adhere into getting the work done well.

> *Managerial approaches* include: establishing new tools to replace familiar ones to support routine tasks, introducing new features and procedures to extend the range of tasks supported by new tools, and integrate new tool use with an agile mindset regarding overall development approaches.

5.2 Techniques

Confusing Minimal Viable Product (MVP) with Minimum Marketable Product (MMP). Where MVP focuses on validating assumptions and learning about users' preferences – this level of work should remain internal to the team. In contrast, MMP incorporates a core set of functionalities that addresses customer/user needs, creates the desired user experience, and can start creating quantifiable value for the business. It can be released to the customer. This distinction

is important to keep in mind because there are necessary elements to products that are being released that go beyond those that affirm that the central functionality is useful to the customer. For example, the user may not directly interact with automated backup, internal documentation notes, peak load capacity, or potential for errors with useable but not fine-tuned interfaces. Managerial actions include establishing a checklist of "behind the scenes" standards checked and refined, when needed, before releasing even approved products to the customer.

> *Managerial approaches* include: establishing a continued and consistent focus on value creation throughout the development process consistent with an agile mindset.

Reframe Stages. Highsmith [15] presents and details an alternative stage model for agile projects. The early stages focus on envisioning the goals of the project and building the initial backlog and planning releases. Exploration involves work iterations to build both the detailed elements that create value and the technical elegance to realize these. these are followed by the mechanics of putting the creations into use, including launching and refining particularly, if necessary, capacity and security issues need to be addressed relative to differences in development and production environments. Development should be behind firewalls, but when the new system moves to the production environment, it needs an additional review to ensure security.

> *Managerial approaches* include: reinforcing the flexibility within the overall stages and effectuate useful fit in the production environment.

INVEST. Developing user stories may seem straightforward, but there are six attributes of effective user stories [16]: independent; negotiable; valuable; estimate-able; small, and testable. These provide tools for evaluating the quality of user stories. It is very practical to assess each user story on the basis of these criteria as well as for writers of such stories to embed these characteristics more and more automatically into new ones as they create them. The application of these criteria is fairly routinely made when working with business analysts who have received certification but much less common with business analysts or project managers that are not certified and not inculcated with this perspective. This is important to emphasize because without attention being called to these attributes of good user stories, many assigned this task just do not do it well. Those trained in information requirements are often not good at disaggregating user stories. When the project team is given epics, they become the ones to break them down to the level where they can be handled in an ad hoc manner. Undertaken by someone adept at this, the team can minimize "fumbling around" and reinventing the wheel. It is really an art form writing really good ones.

> *Managerial approaches* include: working with team members and clients to define user stories at the right level following the hierarchy of Epic > Feature > User story > sub-Task, encouraging team members to pursue the Professional Business Analyst program from PMI (or equivalent courses from other institutions).

Art of the backlog. Managing the backlog is an art, at least as much as it is a science. Disaggregation needs to break epics into user stories, so that team members can have the appropriate amount to chew; getting the right person to do the disaggregation. This contrasts with decomposition, which breaks modules into submodules where they reside without considering the relative value of how they are subdivided.

> *Managerial approaches* include: recruiting a product owner who takes ownership (who represents the "single ring-able neck"), understands and can break epics into user stories, and interpret the business value in terms of technical actions.

Story point estimation. Story points are difficult to comprehend and do not have a single standard, but rather can vary in how they are assigned. Some team members go straight to hours for estimation of effort, but this can be problematic when shifting to agile. Even normalized story points where one equals about four hours of work, three a full day, and so on can absorb unproductive time in the estimation process. Another approach to story points is to estimate them relatively, rather than in absolute terms. Setting a standard point value on the easiest story with a score of, say 3 on a scale of 10, allows all the other stories to be estimated relative to that first one. An easier than standard story maybe a 1 or 2, where a more difficult one can be rated up to 10. Thus, like with Analytical Hierarchical Process [17] cognitive load is eased by using pair-wise comparisons. The risk with time estimates is of taking a great deal of effort just in the estimation process, with the estimates turning out to be notoriously inaccurate anyway. With the user story, work is

defined in terms of benefit to the user in contrast to the traditional project management concept of a work package viewed in terms of internal activities. Assessing accomplishments of an agile iteration are the product of the story point estimation and the amount of value delivered by each user story so that the accumulation of large numbers of low-value tasks are not necessarily appreciated more than a moderate number of higher-value tasks.

> *Managerial approaches* include: establishing a continued and consistent shift from the estimation of time by task to comparative estimation.

Representing the architecture. Particularly as the size of the project scales, creating independent features which move forward value for the client, it is necessary for all team members to be extending the same base product. When it is necessary for one team member to adjust the base product in order to facilitate the smooth operation of a new feature, it is important that this change becomes part of the representation of the base product that all team members are continuing to work from in the case where such a change does not affect other components but most importantly when it does (or where its effects may not be immediately apparent.

> *Managerial approaches* include: assigning responsibility for selecting, using, and updating architectural model(s) at the level of detail necessary for streamlining processes for adding new features.

Issue lists. Distributed teams may each be committed to different tools, even if the final product needs to be written in one language. Such an issue needs to be recognized, listed, and "time-boxed" for the project manager to resolve, even if a unilateral and perhaps arbitrary decision is required. Similarly, issues of risks including potential adverse events, exceptions, proposed changes, and the like, need to be created. To complete their usefulness they must be augmented with monitoring and action taking where needed.

> *Managerial approache*s include: establishing a list of issues to be recorded as they arise and resolved at the first opportunity.

5.3 Summary

Table 4 summarizes the tools and techniques factors.

Table 4. Tools and techniques factors.

Factor	Description
Tools	
Chargeback versus overhead	Shifting to tools designed for agile is a critical part of its adoption. Charging individual projects for tools is a sure way to stifle their adoption.
Full use of tools	Software tools for agile are extremely effective when, and only when, associated with the additional elements of the method that provide the governance for project progress.
Techniques	
Confusing MVP and MMP	The MVP is used for understanding and communication but rarely is ready for release into production. Much of the MVP work can be conducted manually behind the scenes in ways that are not visible for users in practice. The MMP cannot exist without the existence of at least one MVP.
Reframe stages	Early stages need to focus on visions of creating value rather than technical or even business requirements.
INVEST	High-quality user stories are more efficient to translate into useful systems and components.
Art of the backlog	Managing the backlog is an art, at least as much as it is a science.
Story points outperform time estimation	Shifting the emphasis from exact time estimates to approximate ones while also accounting for value created as well as work performed.
Representing the architecture	Modeling the base product into which the individual components fit and enable the architecture to evolve
Issue lists	Traditional project management (often outside either pure SDLC or agile guidelines) recognizes, lists, and addresses issues ranging from technical disputes to change requests in a standardized and comprehensive manner.

6. Conclusion

As with any study, the reader must keep in mind its limitations when drawing conclusions. In this case, some constraints that the reader should take into account are: (1) even though our domain knowledge expert has worked on a wide range of projects, portfolios, and programs across a good deal of industries, similar deep investigations with other experts may reinforce some lessons, refute others, and provide a range of additional ideas that can be applied to managing the transition to agile forms; (2) our domain knowledge expert has practiced exclusively in the United States and, more specifically, in the Midwest of the US, although members of his teams have been spread around the world, so encountered practices may differ markedly with other cultures and other regulatory regimes; and (3) our domain expert has worked exclusively with organizations that are primarily users of information technology, though some create many applications directly sold to customers as product or service. However, these are not software companies in the sense of broadly selling software tools for users to develop in their own way, as would be exemplified by Microsoft, SAP, or Adobe.

Although a good deal of knowledge was surfaced through our iterative interview process, as is typical, much more remains to be investigated. For example, a number of trends may affect the technical infrastructure and motivation supporting agile approaches. Cloud computing can enable agile teams as it supports team self-organization. The developers can decide how to build their cloud environment in a more decentralized (modular) way and often without long approval processes for new hardware and software. More general management shifts from traditional control and command mode to transformational and collaborative forms may also affect the headwinds as well as the demand for agile development methods.

Naturally replicating this study using similar or varied methods would be important to verify the efficacy of the lessons, surface new ideas, and qualify when, where, and how these lessons can be effectively applied. On the other hand, the possibility is raised of using these ideas to pose probing questions that extend this work. Open remaining questions include:

1. From an individual and team perspective, are there ways to ease the initial learning process for mastering the agile approach? Are there ways to continue evolving the agile approach to make it even more effective? Are there ways to ensure that all team members, agile coaches, and senior leaders are immersed in the “agile mindset”?
2. From an organizational perspective, assuming that a good working alignment is achieved between project teams and senior managers, how are these maintained, and how are the successes accrued using agile reinvested into continual process improvement? For example, are there particularly effective ways to calculate the net financial outcomes balancing project and allied costs versus the actualized benefits from the new products?
3. From a tool and procedure perspective, are there straightforward, perhaps even automated, ways to follow emerging best practices and incorporate new tool features as they are invented, for example, extensions of metrics and analytics to accelerate best practice? Are there better ways to estimate use story points?
4. From an academic perspective, are there heuristics for the use of multiple approaches (assigning projects to traditional or agile rather than using either exclusively) – if so, are there ways to minimize costs associated with such multiple approaches?
5. From an academic perspective, is the use of project management technique to serve as a “buffer” between management stakeholders and team members relatively effective compared to other sorts of hybrid approaches that actually combine traditional and agile method components?

This viewpoint is written in the spirit of extending our understanding of the implementation of agile and hybrid methodologies at a detailed level based on actual work experience. There is a growing belief that agile practices are "better" than traditional ones. Evidence and anecdotes suggest this is true in many cases. They are clearly being adopted widely by organizations. However, the successful movement from traditional to agile often ends up with a sort of hybrid which may take uncountable forms. Moreover, the transition to using agile among teams that have deeply embedded traditional practices takes ingenuity, patience, persistence, and some strategy. This viewpoint discussion is intended to highlight the lessons of an expert project/portfolio manager who has effectuated such transition both as an organizational employee and as an external consultant. The overall theme is less about integrating traditional and agile components and more about using traditional project management techniques customized to the agile environment in order to provide an alignment between the working culture of the team members and the monitoring culture of senior leaders. Additional themes running through these various more detailed lessons and observations are:

1. The project manager can intervene with management allowing team members to use an agile technique to create positive organizational value in a more spontaneous discovery-oriented mode while providing data regarding the progress that senior managers are used to and need for their own strategic decision making;
2. The movement from a traditional to agile-oriented approach requires much learning on the part of typical team members, but single doses of training sessions should only be viewed as the beginning to be reinforced over time in a persistent manner until the mindset and practices become habitual;
3. Tools and procedures can be used together to create new work practices and support them using tools designed for those purposes.

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In whom do we trust? Critical success factors impacting intercultural communication in multicultural project teams

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In whom do we trust? Critical success factors impacting intercultural communication in multicultural project teams

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Abstract:
Trust is a significant enabler for intercultural communication in project teams. Researchers and practitioners, therefore, need to know which factors might enhance trust in intercultural communication. Contributing to the yet limited number of studies in the field of intercultural communication for multicultural project teams, this research theoretically analyzes and empirically investigates the enablers of trust for intercultural communication focusing on emotional intelligence, empathy, interaction, and transparency. Using a field sample of 117 experienced project managers working in multicultural project teams, we find that interaction and transparency significantly and positively influence trust in intercultural communication; empathy marginally and positively influences trust. Emotional intelligence does not exert an effect on it. These results provide novel theoretical and empirical insights which have practical implications for project managers. The findings direct suggestions for additional theoretical work.

Keywords:
trust; intercultural communication; project teams; emotional intelligence; empathy; transparency.

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1. Introduction

In recent years, the ubiquity of multicultural teams has drawn attention to intercultural communication (ICC) and the benefits and challenges it brings. Project success is tightly linked to successful communication between stakeholders [1], [2]. However, international projects can suffer from ambiguous communication [3] and poor cross-cultural communication [4]. Ochieng and Price [5] maintain that achieving project success is made considerably more complex within multicultural project teams characterized by dissimilar organizational and regional cultures. Research shows that companies with highly functioning multicultural teams are better placed to succeed in international projects [6], [7] and that international companies are currently making great efforts to realize the benefits of effective intercultural connection and cultural diversity on project performance [8]. Hence when implementing project plans, the roles of culture and intercultural communication (ICC) competency in multicultural teams are becoming increasingly evident. A better understanding of ICC in multicultural teams will allow project managers to develop feasible solutions to intercultural communication conflicts; improve their ability to deal with complicated group issues aggregated by diversified cultures [9] and maintain competitive advantage within globalized settings [3]. However, although the significance of ICC has been highlighted by researchers and practitioners, research on managing the communication challenges confronting multicultural project teams over individuals [10] has been largely neglected. Moreover, our understanding of ICC remains deficient in the following ways.

First, Barker [11] argues that scholars often see cultural differences as sources of misunderstanding and conflicts, which negatively affect communication. He suggests that too much emphasis is placed on the management rather than the appreciation of cultural differences. He argues that an awareness of the difference does not mean transforming everyone into the same style. Instead, Barker [11] explains that project managers should motivate the team to be curious about and respect different cultures. Consequently, the challenge in building effective communication with staff from different cultures persists [8], [12]. Researchers are thus calling for more investigations into the influential attributes of ICC [8], [13]. Moreover, Martin [14] states that, there is no satisfactory, comprehensive conceptualization of intercultural communication. Therefore, academic inquiries that seek to gain a more fine-grained understanding of the concepts and enablers of intercultural communication are necessary.

Second, a thorough review of the extant literature on the antecedents of ICC indicates the importance of constructs such as commitment [15], [16], the ability to cooperate [17] and interpersonal skills [18]. It also reveals that *trust* is a significant enabler for ICC [5], [16], [18], [19] and that a lack of trust contributes significantly to communication breakdown and can lead to management failure of multicultural teams which in turn obstructs project success. Although trust is viewed as a core element in building confidence and emotional bonds [20] and it leads to increased knowledge sharing and reduced task uncertainty [21], it is difficult to develop trust in the multicultural environment because it is an elusive, dynamic and complex concept [22]. While much of the literature points to the importance of trust, the role trust plays in ICC remains ambiguous. There lacks a clear framework and effective measurements for trust in ICC.

Third, previous researchers have explored the enablers of trust in project teams. For instance, Rezvani [17] investigated how emotional intelligence influences trust in hydropower project teams; Akgun et al. [23] found that empathy and trust are positively associated with each other in software development project teams; Wong et al. [24] examined multi-type project teams and proposed that interaction is important for trust-building in project teams. Mesly [25] focused on construction project teams and asserted that transparency influences the development of trust in teams. However, research on *multicultural* project teams is still limited and underdeveloped. One notable exception is a qualitative study conducted by Ochieng and Price [5]. They focused on multicultural construction project teams in Kenya and the UK and examined the critical success factors (CSFs) for trust. Since everyday work has become increasingly international and project centric, these aforementioned lines of research must be extended and supported with more empirical studies within multicultural teams. This will extend the validity of trust in ICC into multicultural project teams and provide practical learnings for project managers who seek to implement best practice in international organizations toward effective intercultural communication.

In addressing these research gaps, this study attempts to address these deficits by focusing on the critical success factors for trust in ICC from the perspective of multicultural project teams comprising individuals from different cultural backgrounds working in international companies. This paper thus underpins, qualifies and amends existing evidence by shedding a quantitative light on the questions:

1. What are the critical success factors for trust in ICC in multicultural project teams?
2. Whether and how do emotional intelligence, empathy, interaction, and transparency impact trust in ICC in multicultural project teams?

We address these research questions by applying communication theories and project management concepts to better understand ICC issues incurred by multicultural project teams. More specifically, we conduct a comprehensive literature review to identify, define, categorize, and aggregate the factors that can facilitate the achievement of trust in the field of project management. Four enablers of trust emerge, namely emotional intelligence, empathy, interaction, and transparency. These concepts serve as the foundation that underpins our hypotheses, research method and findings. We analyze real-world data from 117 experienced project managers working in a multicultural environment using SPSS and Partial Least Squares (PLS). Finally, we draw conclusions and discuss the implications of the study for future research.

This research makes significant empirical, theoretical, and practical contributions. Theoretically it provides an advanced understanding of the concepts of trust and its critical success factors in the context of project management. Further it presents a theoretical framework, an empirical analysis and it also provides effective measures for the enablers of trust in ICC. Most importantly, the results of this study are expected to add to existing research by highlighting the critical role of trust in integrating teams in assisting practitioners to achieve high levels of team communication when communicating in an intercultural project context.

The remainder of this paper is structured as follows. The next section presents a brief review of the extant literature on ICC in multicultural teams, the benefits, and challenges of trust in ICC and the success factors for trust in ICC, whereas section three presents our research model and proposed hypotheses. It is followed by a description of the research methodology and data collection procedure. We then present the results of the data analysis and related discussions. Finally, we draw conclusions and discuss the implications of the study for future research.

2. Literature review

2.1 Intercultural communication skills in multicultural project teams

Scholars in the field of project management have researched team effectiveness, team communication and trust for decades. More recent changes in practice have led to a focus on multicultural teams and thus intercultural communication (ICC). Researchers have identified benefits associated with multicultural teams in projects. For example, multicultural teams are lauded to bring fresh ideas to the workplace and to projects [5]; they are associated with high levels of team performance [4]; better relationships are developed between team members [9] and multicultural teams have been shown to help maintain competitive advantage [3]. However, human communication is shaped by culture and because cultural communication patterns are acquired and internalized at a very early age, people are generally unaware of them.

ICC incorporates cognitive, affective, and behavioral attributes, which Chen [26] conceptualizes as intercultural awareness, sensitivity, and adroitness, respectively. To better understand the concept of intercultural communication in project management, Gudykunst [27] defines it as the interactions among human beings from diversified cultural backgrounds with various patterns, styles, and preferences in communication. This perspective has been adopted by many researchers in this specific area for the past ten years [28].

Scholars emphasize an awareness of culture in ICC and suggest that providing a sense of belonging and security within teams is the key to the successful management of ICC. Further investigations into how to provide a sense of security and successfully manage ICC led to a preliminary list of constructs considered essential to effective ICC, including

commitment [15], [16], ability to cooperate [17] and interpersonal skills [18]. Further, *trust* is shown to be a major antecedent of ICC dominant to all other concepts [5], [9], [18]. Research indicates that cultural difference does not pertain to one specific individual difference [15] and the challenge is how to build effective communication in the most appropriate way with individuals from different cultures [8], [15]. In this context, cultural understanding in ICC is more difficult because of the emergence of barriers such as a lack of trust. It triggers misunderstandings, personal bias, and unwillingness to cooperate with others [6].

2.2 The benefits and challenges of trust on intercultural communication

Trust is defined as "a psychological state, which refers to the intention to accept vulnerabilities on the basis of taking a positive attitude towards intentions or behaviors of another" [29]. This definition, which emphasizes the willingness to accept the vulnerability of the relationship, and the positive expectations of another party regardless of the risk of being hurt [30], has been accepted widely in the literature, e.g., [31], [32].

Generally, trust is considered to be an important factor that can reduce the cost in the negotiation and monitoring process. It helps to increase the possibilities for reaching mutually beneficial agreements [33], fostering a feeling of oneness among team members [34], boosting team efficacy [4] and playing a critical role in decision-making [35], leadership development [36] and innovation effectiveness [31]. The effective management of ICC is based on building trust. Trust can help to coordinate team behaviors, enhance information sharing and develop good relationships [37]. In a multicultural environment, trust is crucial because it helps to eliminate the sense of uncertainty among team members [2]. Finally, trust is pivotal to knowledge sharing within organizations, especially those with global virtual teams [38], [39]. Importantly, the corollaries are also true; a lack of trust within teams (and consequently within multicultural teams) has significant adverse consequences on communication as evident in the literature. These are summarized in table 1.

Table 1. Consequences of a lack of trust.

Consequence of lack of trust	**Context**	**Reference**
Difficult to manage or supervise multicultural project teams	Empathy in leadership	[5]
When caused by cultural differences, it has a negative impact on communication in global virtual teams	Communication breakdown in global virtual teams	[18]
Decreases the possibilities of reaching mutually beneficial agreements	Trust building in international construction	[33]
Leads to failure in the development of strategic partnerships	Commitment, trust, and cultural sensitivity in strategic partnerships	[40]
Leads to poor relationship caused by issues of well-being, such as the sense of isolation and increased mental workload	Basis of trust in virtual work settings	[41]
When it emanates from top management, it generates an unsafe communication climate within the organizations.	Organizational climate in large-scale projects in the oil and gas industry	[42]
When caused by physical distance, it leads to poor cooperation in international projects	Building trust in international projects	[43]

Consequence of lack of trust	Context	Reference
A negative impact on project success in complicated project situations	Building trust in complex projects	[30]
Reduced knowledge sharing in the intercultural environment	Knowledge sharing across subgroups in global virtual teams	[39]
When caused by time-zone differences, it can negatively influence a healthy work-life balance	Working in global virtual teams	[44]
Leads to process and relationship conflicts among team members	Relationship between communication-conflict interaction and project success among construction project teams.	[37]
Causes problems such as clashes of communication styles, misinterpreted messages and bold statements perceived as impolite messages	Intercultural communication styles of global virtual teams during distributed decision making	[4]
Negatively influences overall team performance	Building trust in construction projects	[30]

In a multicultural context, trust is the foundation that makes team members feel a sense of belonging and security. Without trust, feelings of isolation and unwillingness to collaborate can arise, leading to project failure. To better measure trust in the multicultural environment, it is essential to identify which critical success factors of trust have been emphasized in the literature.

2.3 Critical success factors for trust

According to the classical research study conducted by Bullen and Rockart [45], the term, critical success factor (CSF), is conceptualized as "key areas where "things must go right" to successfully achieve objectives and goals". Bullen and Rockart [45] also underlined a method of reviewing, classifying and aggregating literature to acquire CSFs. Following their process, our research conducted a thorough literature review on the success factors of trust in the field of project management. Therein, we identified, defined, categorized, and ranked these enablers. Finally, and in line with the literature, four key success factors emerged as the most prominent enablers namely emotional intelligence, empathy, interaction, and transparency. Table 2 defines these four CSFs and presents the context, research methods and findings derived from relevant previous studies. As shown in Table 2, emotional intelligence [24], [30], [46], [47], empathy [4], [5], [46], [48], interaction [5], [24], [49] and transparency [25], [50], [51], [52] have been proven to positively influence trust. However, while most of these studies concentrated on investigating project teams, little attention was given specifically to *multicultural* project teams. Although Ochieng and Price [5] focused on multicultural construction project teams in both Kenya and the UK, they examined critical success factors (CSFs) of trust, they employed qualitative methods. Therefore, quantitative empirical studies are urgently needed in order to extend the external validity of trust in ICC in the context of multicultural project teams.

Table 2. The definitions of critical success factors of trust in ICC and its related studies.

Success factors	Definitions	Previous studies	Context	Research methods	Findings
Emotional intelligence	The ability to recognize, understand, control and exploit emotions [50] to guide one's thoughts and actions in a positive direction [27].	Clarke [46]	Project teams (in Management Institute)	Quantitative study (67 UK project managers)	Emotional intelligence explained additional variance in project management competence.
		Rezvani et al. [30]	Project teams (in hydropower industry)	Quantitative study (408 project managers and project members)	Emotional intelligence relates positively to trust at different levels of analysis.
		Rezvani et al. [47]	Project teams (in Australian defense industry)	Quantitative study (337 project managers)	Emotional intelligence has a positive impact on trust.
		Wong et al. [24]	Project teams	Quantitative study (163 project manager and project members)	Emotional intelligence is important for trust-building in project teams.
Empathy	The ability to perceive, understand, experience and respond to the emotional state, ideas, values and culture of another person [2], [51].	Akgun et al. [48]	Software development project teams	Quantitative study (122 project managers and project members)	Empathy and trust are positively associated with each other.
		Clarke [46]	Project teams (in Management Institute)	Quantitative study (67 UK project managers)	Empathy explained additional variance in project management competence.
		Matveev and Nelson [4]	Multicultural teams	Quantitative study (124 American and Russian managers)	Cultural empathy as part of cross-cultural communication is positively related to team performance.
		Ochieng and Price [5]	Multicultural project teams (construction industry)	Qualitative research (20 interviews in Kenya and UK)	The creation and development of effective empathy is critical for building multicultural project teams.
Interaction	The process of exchanging information and emotions among individuals [22].	Krawczyk-Bryłka [49]	Intercultural teams	Quantitative study (survey of 200 international students)	Interaction is one of the most important elements of trust.
		Wong et al. [24]	Project teams	Quantitative study (163 professionals)	Interaction is important for trust building in project teams.

Success factors	Definitions	Previous studies	Context	Research methods	Findings
		Ochieng and Price [5]	Multicultural project teams (construction industry)	Qualitative research (20 interviews in Kenya and UK)	Trust depends on the interaction of individuals and interpersonal relationships.
Transparency	Transparency is defined as "openness" with the organization [48].	Auinger et al. [52]	-	Qualitative study	Transparency influences project success.
		Mesly [25]	Construction project teams	Qualitative and quantitative investigation (24 project managers)	Transparency influences the development of trust in teams.
		Parris et al. [51]	-	Systematic literature review	Transparency promotes trust in teams.
		Schilcher et al. [50]	International teams	Qualitative research (case study)	Lack of transparency results in obstacles in the cooperation process

3. Research model and hypotheses

Based on the comprehensive literature review of the enablers of trust in the field of project management, a theoretical framework is developed (see Figure 1). The framework shows how emotional intelligence, empathy, interaction, and transparency influences trust in ICC in the context of multicultural project teams. We next briefly discuss these four success factors and identify the hypotheses tested in the study.

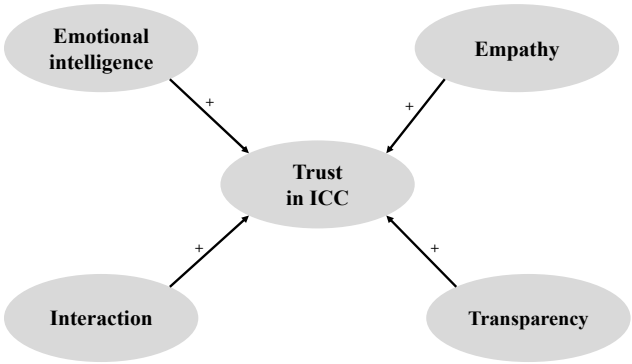

Figure 1. A theoretical framework of the success factors of trust in ICC in multicultural project teams

3.1 Emotional intelligence (EI)

Research has shown that emotional intelligence (EI) contributes to the building of trust in project teams [30], [46], [48]. EI is defined as the ability to recognize, understand, control and exploit emotions [53]. This theory has been extended to assist organizations in cultivating EI to guide employees' thoughts and actions in a positive direction [30]. It is believed

that EI underpins more effective teamwork [30], [46]. For example, emotional competencies, such as the proper articulation of emotions, are conductive to decreasing the misunderstandings caused by language differences [55]. In addition, EI has also been classified as an affect-based trust which creates emotional bonds among team members [24]. Thus, EI contributes to a sense of belonging.

It is therefore expected that EI should play a crucial role in building trust in intercultural communication. However, little research addresses or analyzes EI in multicultural project teams. Although several scholars argue that EI capabilities offer a means to further appreciate aspects of individual differences that can influence project performance [30], [46], few studies discuss what kind of individual emotional differences could impact the whole team and to what extent. Therefore, the first hypothesis we test is the following:

Hypothesis 1: Emotional intelligence is positively associated with trust in ICC.

3.2 Empathy

In globalized teams, a significant challenge for project managers lies in how to effectively guide and communicate with their team when inappropriate communication styles or misunderstandings may lead to a lack of trust. Some researchers, such as Clarke [46] and Young et al. [56], suggest empathy is a solution. Empathy is conceptualized as the ability to perceive, understand, experience and respond to the emotional state, ideas, values and culture of another person [4], [54]. In a multicultural environment, cultural empathy is important. This refers to the capability to see, understand and appreciate the world from others' cultural perspectives [4]. Empathy has been considered to be an essential competence for project managers, and is associated with better teamwork, attentiveness, and the management of transformational leadership in multicultural environments [46]. Researchers such as Clarke [46] and Ochieng and Price [5] have concluded that the key components of empathy are respect, openness, and curiosity towards other cultures. They contend that empathy is created by these essential components which contribute towards developing trust in multicultural teams.

Therefore, it would appear wise for project managers to cultivate higher levels of empathy when communicating with colleagues from different cultural backgrounds. However, there lacks sufficient literature studying the relationship between empathy and trust in ICC in multicultural project environments. Researchers have questioned whether empathy would completely solve the presence of misunderstandings and distrust in multicultural projects [15]. Furthermore, too much empathy might lead to weaker decision-making competency [46]. For example, if project managers pay too much attention to encountering different working styles, they might neglect other factors such as time and budgets that are more crucial to the project success. Consequently, we test the following hypothesis:

Hypothesis 2: Empathy is positively associated with trust in ICC.

3.3 Interaction

Interaction is defined as the process of exchanging information and emotions among individuals [24]. At a team level, effective interaction facilitates better knowledge transfer and cohesion in organizations [57]. Recent studies have emphasized that interaction is an essential construct for trust in project management. Areas of study include the communication process in construction projects [24]; team engagement in inter-organizational projects [31]; communication frequency in global virtual teams [57] and interaction engagement in multicultural teams [15]. These studies have shown that interaction is essential for building trust within multicultural project teams because it creates the channel for sharing information and emotions. Also, active interaction develops a stable environment for work and motivates the team for effective communication within complex projects. These benefits are lauded to lead to a more satisfying relationship between project managers and team members [3].

However, it is challenging to define one kind of interaction that best suits multicultural teams because communication styles are diversified and fluid rather than fixed [3] and different cultures have different preferences. Therefore, the theory of the host culture becomes dominant [11]. This in turn complicates understanding the relationship between interaction and trust in a multicultural environment. For example, if the employee works in a high context office, he/she

must rely heavily on non-verbal ways to express opinions. Here communication focuses on context, meaning, and tone in the message and not only the words themselves. Therefore, studies related to this specific topic are subject to cultural context. Many scholars follow Hall's theory [58] which considers high context (i.e., close connections over a long period of time) and low context (i.e., many connections of shorter duration) to discuss different communication styles. Following this theory, this study focuses on a "high context" because there is insufficient literature studying ICC in a high context environment. Consequently, the following hypothesis is tested:

Hypothesis 3: Interaction is positively associated with trust in ICC.

3.4 Transparency

Transparency has been recognized as the foundation of a fair environment for ICC [19] and conceptualized as "openness" within the organizations [51]. With no consideration of personal issues, it emphasizes formalizing the process and providing equal opportunities. Creating a transparent environment for the team develops trust as a sense of security, corresponding with Maslow's hierarchy of human needs [55]. When project managers meet their security needs, they can then move to the higher level of social needs. At this stage, they become more collaborative with others. Researchers have studied different aspects of transparency in organizations regarding the topic of trust in project management. Examples include transparency in organizational policy and process clarity in construction projects [37]; transparent rewards in inter-organizational projects [31]; transparency across different stakeholders in R&D projects [55], overall transparency in international projects [25] and role clarity in global virtual teams [19]. According to this body of work, transparency is crucial to developing trust because it creates an open and honest communication platform for multicultural teams. Transparency is thus positively related to the formation of trust. Furthermore, transparency in policy, process, responsibility, and rewards distribution supports project success. In global organizations, a lack of transparency can cause confusion which can lead to conflicts and culminate in project failure. Therefore, transparency contributes toward building trust in intercultural communication. This leads to our next hypothesis:

Hypothesis 4: Transparency is positively associated with trust in ICC.

4. Methodology

4.1 Data Collection

In our research, the proposed hypotheses are examined using data elicited from experienced project managers working in multinational companies in the automotive industry. The sampling frame consists of project managers from multiple functions who had at least three years' experience leading multicultural project teams. There are two main reasons why project managers were chosen as the target for this study. First, the value of their competencies makes them one of the most crucial enablers for project success as advocated by many researchers [59] [60]. Second, while previous studies that explored the enablers for trust have also targeted the project manager [25], [46], [47] we believe that this line of research should be extended to include project managers operating in multicultural project teams. It is hoped that the results from this study can provide practical suggestions to project managers who seek to optimize effective intercultural communication operating in multicultural environments. Relevant subjects were identified via the human resource functions in the organizations. Empirical data was collected using an online survey instrument. The questionnaire included two types of questions. Firstly, two nominal questions associated with the basic features of the target audience namely gender and relevant work experience were posed. Secondly, forty statements derived from the literature were presented and respondents were asked to assess the extent to which they agreed with them using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Several actions were taken to mitigate non-response bias. A cover letter accompanied the email explaining the rationale, defining the core concepts and requesting participation in the study. Respondents were informed that the questionnaire would take less than 10 minutes to complete. The respondent's anonymity was guaranteed. Important psychometrics parameters [51] were also followed, such as adopting familiar terminology and shortening the statements to enhance meaning when modifying items on the survey.

The questionnaire was pretested (n=6) and pilot tested (n=10) to ensure the technical reliability of the instrument and adequate comprehension of the questions. Minor changes were made following this analysis which helped to strengthen the construct validity and decrease possible misunderstandings. The instrument was distributed to 880 project managers with experience in managing multicultural project teams between March and May 2019. After one month, we received 117 usable responses, representing a response rate of 13%. This final sample included diversified profiles of top and middle-level employees. 60% of respondents were male and 40% female; 65% of the respondents had between 5- and 10-years' experience, 22% had more than 10-years' experience and 13% has between 3- and 5-years' experience.

4.2 Measures

Emotional intelligence was assessed using four items (α = .739) developed by Wong et al. [24] and Rezvani et al. [30], from the perspective of understanding, managing and perceiving emotions. See Table 3 for a list of items used in this study.

Empathy was measured using five items (α = .751) proposed by Matveev and Nelson [4] and Wong et al. [24], comprising the dimensions of respect, communication, appreciation, and collaboration.

Interaction was assessed using five items (α = .760) created by Wong et al. [24] and Wu et al. [37]. The items measure information, knowledge sharing and communication (see Table 3).

Transparency was assessed using five items (α = .759) proposed by Park and Lee [57] and Caldwelll and Clapham [61] from the perspective of responsibility, rewards, terms, and conditions.

Trust was measured by employing five items (α = .885) developed by Rezvani et al. [30] and Tsai et al. [62].

Table 3: Constructs and measurement.

Constructs	Items	Reference
Emotional intelligence	I can explain the emotions I feel to team members. I can overcome my frustration when I am frustrated with my team members. I am aware of team members' true feelings. I can handle difficulties rationally.	[30]
Empathy	I respect other people's values. I can communicate effectively in a one-to-one form. I can communicate effectively in the group form. I am able to appreciate dissimilar working styles. I feel comfortable working with people who come from different cultural backgrounds.	[4], [24]
Interaction	I can share information accurately with the team in meetings. I have enough information to make timely decisions. I can have better information sharing by regular meetings. I adopt visual methods to reduce communication barriers in the workplace. I can acquire more useful knowledge by more access to information platforms.	[24], [37]
Transparency	I can clearly define team members' responsibilities. I can clearly define team members' tasks. I make the project rewards equitable. I can clearly explain information in the contracts to those who may be affected. I clarify terms and conditions before the commencement of work.	[57], [61]
Trust	If I get into difficulties at work, I know my team would try to help me out. I can trust my team to help me if I need it. I have full confidence in the skills of my team. I can rely on most of my team members to do as they say they should do. I can rely on my team not to make my job more difficult by careless work.	[30], [62]

Control variables. We included controls for the effects of (a) gender and (b) working tenure. Previous researchers, such as, Maddux and Brewer [63] found that there is a significant difference between men and women concerning trust; and Chan and Mak [64] suggested that subordinates' organizational tenure influences their trust in leaders. Therefore, to address these possible alternate explanations for our constructs, we controlled for these two constructs. They are measured by two nominal questions in the survey.

Partial least squares structural equation modeling (PLS-SEM) analysis was used to assess the reliability of our instrument and to establish the relationship between the different CSFs and trust. PLS is a well-established technique for estimating path coefficients in structural models [65]. This approach has been applied by many researchers in recent years because of its ability to handle complex models with many constructs and indicators. In addition, it can also model latent constructs under conditions of non-normality and it can handle small to medium sample sizes [65], [66]. Furthermore, it has been widely adopted in the Management discipline, see [67], [68], [69] and it is particularly suited to exploratory research that focuses on theory development [66]. Considering these benefits, the PLS technique was adopted in our study, and we used Smart PLS version 3.0 to analyze data collected.

In order to validate our measurement model, we assessed internal consistency reliability, content validity, discriminant and convergent validity. First, we tested for internal consistency reliability using composite reliability measures (CR) [66]. Our results show that CR values are 0.817 (emotional intelligence), 0.833 (empathy), 0.836 (interaction), transparency (0.838) and 0.916 (trust), which are above the acceptable levels [70]. Second, the content validity of our instrument was developed from previous studies. Moreover, the measures in our research were constructed by utilizing constructs that have been validated by other scholars. Third, the discriminant and convergent validity were examined by indicators of Heterotrait-monotrait ratio (HTMT) as well as average variance extracted (AVE) respectively [66]. Our results indicate that the HTMT values ranging from 0.565 to 0.787 are lower than the cut-off value 0.85 [71]. Moreover, the AVE values are acceptable [67], as they exceed 0.5 (emotional intelligence, 0.538; empathy, 0.5; interaction, 0.507; transparency, 0.511; and trust, 0.685).

4.3 Results

SPSS 23 was used to calculate the means, standard deviation, and zero-order correlations of our constructs (see Table 4). As illustrated in Table 4, the results show that emotional intelligence is not significantly related to trust (r = -.13, p > .05). However, empathy (r = .38, p < .001), interaction (r = .41, p < .001) and transparency (r = .35, p < .001) are positively associated with trust. To further test emotional intelligence, empathy, interaction, and transparency as critical success factors of trust in intercultural communication in multicultural project teams, we conducted the inner structural model analysis. The results are reported following the guidelines proposed by Hair et al., [66] (Table 5 and Figure 1).

Table 4: Means, standard deviations and correlations of study constructs.

Constructs	Mean	SD	1	2	3	4	5
1. Emotional Intelligence	3.92	0.71	-				
2. Empathy	3.88	0.70	-.14	-			
3. Interaction	3.95	0.58	-.02	.49***	-		
4. Transparency	4.37	0.50	.12	.16	.36***	-	
5. Trust in ICC	4.27	0.43	-.13	.38***	.41***	.35***	-

Note: N = 117; *p < .05, **p < .01, ***p < .001

First, as shown in Table 5 and Figure 2, emotional intelligence does not significantly exert an effect on trust (β = -0.17, p > .05). Hypothesis 1 (Emotional intelligence is positively associated with trust in ICC) is thus not confirmed. Second, our result illustrates that empathy marginally and positively influences trust (β = 0.17, p < .10), which partially supports hypothesis 2 (Empathy is positively associated with trust in ICC). Third, we find that interaction (β = 0.24, p < .01) and transparency (β = 0.24, p < .05) have significant and positive effects on trust. Therefore, hypothesis 3 (Interaction is positively associated with trust in ICC) and hypothesis 4 (Transparency is positively associated with trust in ICC) are fully supported. Furthermore, among empathy, interaction and transparency, our result suggest that interaction is the most influential critical success factor for trust in ICC.

Table 5: Results of the inner structural model analysis.

	Trust in ICC		
Critical success factor	*β*	SD	t
Emotional Intelligence	-0.17	0.12	1.459
Empathy	0.17†	0.09	1.886
Interaction	**0.24****	0.09	2.643
Transparency	0.24*	0.09	2.592
Control variables			
Gender	-0.05	0.08	0.664
Working tenure	-0.13†	0.08	1.658
R^2		.305	

Note: N = 117; †$p < .10$, *$p < .05$, **$p < .01$

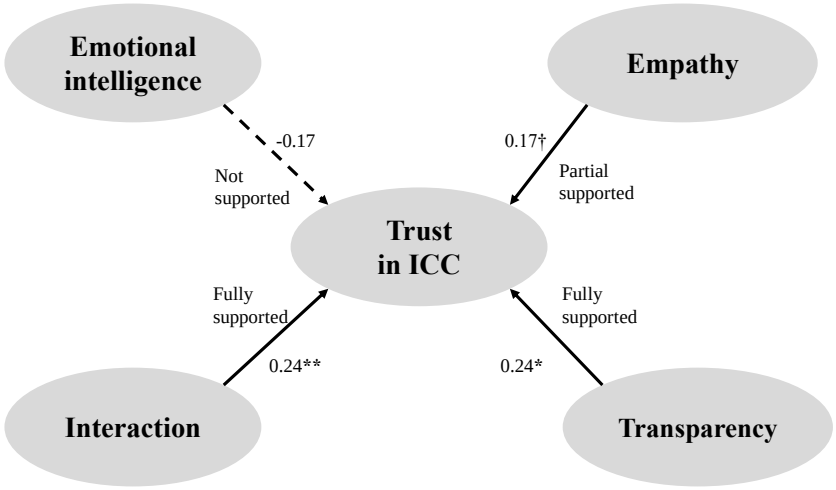

Figure 2. The findings of our research

5. Discussions and implications

Integrating literature on communication theories and project management concepts, this research sheds light on our understanding of what, whether and how hypothesized critical success factors influence trust in ICC. To our knowledge, this study is among the first efforts to theoretically analyze and empirically investigate the enablers of trust in ICC in multicultural project teams. In doing so, we find that interaction and transparency have significant and positive effects on trust in ICC; empathy marginally and positively influences trust. Interestingly and unexpectedly emotional intelligence does not exert an effect on it. In the following section, we discuss these findings, seek to place them in perspective and describe the results and their significance in relation to the overall study.

First, our results indicate that high-quality interaction, is the most important critical success factor as it significantly and positively influences trusts in ICC. This result suggests that information, knowledge sharing, and communication (as elements of interaction) are essential to building trust in multicultural project teams. This finding is consistent with previous research conducted by Wong et al. [49] and Krawczyk-Bryłka [49]. It implies that ongoing interaction helps project teams to distribute, understand and obtain meaningful information and knowledge [24]. It forms a bridge for

information exchange and thus fosters trust-building in project teams. Interestingly, table 4 shows that empathy and interaction are significantly and positively associated with each other ($r = 0.49$, $p < 0.001$). It is a noteworthy finding because this association has not been emphasized in the literature. The result suggests that the competency of empathy may be enhanced when there are more opportunities to interact with others. Therefore, project managers need to be cognizant of the importance of working with people from different cultures by communicating more frequently with them. In sum, trust can be more readily built within multicultural project teams by fostering improved empathy and increased levels of interactions within teams.

Moreover, the strong linear correlation result between transparency and trust indicates that transparency forms the foundation of trust within multicultural project teams. In our survey, we find that project managers regard maintaining transparency in responsibilities, rewards, terms, and conditions as important principles. These findings support previous work, e.g., Wu et al. [37], who proposed that transparency in organizational policy and process clarity fosters trust; and Maurer [31] who argued that transparent rewards promote trust building. The reasons that transparency is an important critical success factors for building trust in ICC lies in the fact that transparency brings a fair and trustworthy platform for multicultural project teams. However, excessive transparency may create upheavals, such as disclosing industrial secrets [25]. We, therefore, encourage future studies to explore the extent to which transparency is most beneficial to intercultural project teams. Furthermore, based on our findings that maintaining transparency is of vital importance to developing trust in multicultural teams, we recommend that project managers strive to make work tasks and responsibilities very clear to team members. Meanwhile, project rewards must be equitable and channels for information sharing and administration processes should be transparent. This will be beneficial to both building trust and to effectively managing multicultural teams.

The study results further indicate that cultural empathy is a critical success factor for trust in ICC. While the path is weak, it is positive and significant at the .1 level thus supporting Hypothesis 2 that proposes that empathy exerts a positive impact on trust. The significant role of empathy when developing trust within multicultural teams has been emphasized by many authors including Clarke [46], Ochieng and Price [5], Bell and Riol [15] and Young et al. [56]. Empathetic project managers respect and appreciate colleagues from all cultures. This competency opens the channel for honest and open communication within the team. When misunderstandings arise, their empathy will mitigate the conflicts. Consequently, people form closer bonds and mutual trust can be developed. Interestingly, Table 4 shows that there is no significant correlated relationship between empathy and EI from the test ($r = -.14$, $p > .05$). Furthermore, we also find that the item of "taking cultural differences into consideration when making decisions" had the lowest score. Though project managers admit and accept the existence of cultural diversity, it is not important for them when it comes to big decisions like promotion, task assignment, etc. The result aligns with the argument that empathy should not influence the decision-making process [56].

Finally, the results indicate that emotional intelligence does not significantly impact the formation of trust in multicultural teams. One possible reason for the disagreement regarding EI might be the limited measurements. Also, EI could possibly have a moderating role between empathy and trust, which aligns with the argument that EI is likely to promote empathy in relationship management, leading to effective ICC [30]. Although EI did not directly create trust, its impact on teamwork effectiveness is worth further attention.

5.1 Theoretical contribution

First, by joining a handful of researchers in the field of ICC, this study addresses theoretical gaps relating to the enablers of trust and advances the theory of conceptualizing trust in ICC. Specifically, it develops and contributes a conceptual model of key enablers of trust in ICC and increases our understanding about the CSFs for developing trust in multicultural project teams. Our findings extend the line of enquiry by demonstrating that interaction and transparency have the most significant effects on trust thus supporting cogent work in the field of ICC and project management. We also found that empathy marginally and positively influences trust, and our results indicate that emotional intelligence does not significantly impact the formation of trust in multicultural teams. These results are novel in the sense that no empirical work has explicitly quantified the extent to which certain key antecedents relate to trust in the project management literature.

Another important theoretical contribution is that this study provides interesting insights into the relationship between empathy and interaction. We found that these constructs are significantly and positively associated with each other. To the best of our knowledge, this has not been emphasized in the literature before now.

5.2 Managerial implications

This research also benefits project managers by suggesting ways in which trust can be built in multicultural environments which will support more effective ICC. Improved ICC should lead to positive impacts on project success, customer satisfaction and competitive advantage as indicated in the literature review.

A lack of trust has been identified as a major reason for feelings of isolation and an unwillingness to collaborate within teams which are therefore key barriers to ICC. Only when team members start to understand and trust each other, can they form an integrated team. However, cultural differences, language barriers, and physical distances make it difficult to generate trust in the multicultural environment. Moreover, it is not always cultural differences alone that make people feel isolated. Sometimes anxiety exists based on a fear of rejection. Thus, project managers are encouraged to pay more attention to individual feelings of distrust between team members and actively seek to dispel it.

In conclusion, as our findings have indicated the significance of interaction, transparency and empathy to a lesser extent are pivotal in developing trust in multicultural teams, managers and leaders are strongly encouraged to build more transparent working environments, to facilitate more interactions of high quality within teams and to cultivate cultural empathy competency. By so doing, organizations can foster higher levels of trust, leading to more effective ICC and more successful project management.

6. Limitations and Future Research

The results of this study offer clear indications to managers and researchers on approaches to trust-building that may be beneficial in the context of ICC within multicultural project teams. However, as with all studies some limitations should be noted, along with directions for future research.

This study examined trust as a complex social phenomenon by reducing it to several quantitative scale items. However, it may have neglected different types of trust and other possible mediators/moderators of trust. For example, we did not investigate a moderating role by EI in this study. This is because our research focuses on identifying the critical success factors and their direct influence on trust in ICC. We, therefore, encourage future research to examine possible mediating/moderating factors. Furthermore, studying the model through a multilevel analysis may be worthwhile. For example, empathy and interaction could be studied at the individual level, while transparency could be studied at the group level offering a more comprehensive understanding of trust in ICC. Further investigations might lead to some inspiring results.

It is also challenging to apply the theory of trust to different cultural backgrounds. Therefore, understanding of this complex topic could be improved by comparison research. The theory of anxiety/uncertainty management in the context of cultural differences might be helpful. Also, different cultural backgrounds may affect emotional abilities, empathy competency, communication styles, and transparency assessment [30], [72]. Therefore, a comparative analysis between differing cultural backgrounds would be helpful to advance this research area.

Finally, to validate our research framework, we only controlled two variables, gender and working tenure. We omitted the degree of project teams' intercultural profile, their communication behaviors and team members location (i.e., on-site/dispersed). We thus encourage future studies to include these controls to get more accurate results. Moreover, since our research focused only on project managers from multinational organizations, it limits the generalizability of the results. Therefore, future research can make a valuable contribution by examining the critical success factors and barriers from a wider variety of contexts. A larger sample size would be preferred as would the use of in-depth qualitative approaches such as in-depth interviews to explore employees' opinions about trust.

7. Conclusion

With the number of intercultural teams constantly rising in firms today, there is certainly a need to better understand how project management processes need to be adapted to create trust and increase project success. This study, therefore, investigates several important enablers that influence trust in Intercultural Communication in a multinational corporation. Specifically, we examine the impact of emotional intelligence, empathy, interaction, and transparency on trust. Using data from the field, provided by experienced project managers, we find that cultural empathy, high-quality interaction, and transparency are strongly associated with the development of trust in intercultural communication. These findings 1) extend the literature on intercultural communication in the context of project teams, 2) advance our understanding of how to promote trust and subsequently contribute to intercultural communication, and more importantly 3) provides insightful thoughts to researchers and practitioners regarding critical success factors that can be used by project managers to actively manage how they build trust in multicultural projects.

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Measures related to social and human factors that influence productivity in software development teams

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Abstract:
Software companies need to measure their productivity. Measures are useful indicators to evaluate processes, projects, products, and people who are part of software development teams. The results of these measurements are used to make decisions, manage projects, and improve software development and project management processes. This research is based on selecting a set of measures related to social and human factors (SHF) that influence productivity in software development teams and therefore in project management. This research was performed in three steps. In the first step, there was performed a tertiary literature review aimed to identify measures related to productivity. Then, the identified measures were submitted for its evaluation to project management experts and finally, the measures selected by the experts were mapped to the SHF. A set of 13 measures was identified and defined as a key input for designing improvement strategies. The measures have been compared to SHF to evaluate the development team's performance from a more human context and to establish indicators in productivity improvement strategies of software projects. Although the number of productivity measures related to SHF is limited, it was possible to identify the measures used in both traditional and agile contexts.

Keywords:
software project management; software development productivity; productivity measures; human and social factors.

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1. Introduction

Software development productivity is an interesting research topic within Software Engineering [1] and software project management fields [2]. Productivity is defined as the ratio between the output and input within the software development production process [3], [4]. The output is understood as the amount produced (software artifacts or services, tasks performed, quality, quantity in terms of functions, lines of code, implemented changes, among others), and the input is the effort dedicated to achieve an output (time, effort, labor cost, resources) [3][4][5][6][7]. Therefore, productivity is a key factor in project management and success [8].

Software productivity can be observed from different perspectives, namely, at a development level, a user level, and a management level as follows described: (1) At the development level, it may be related to the number of lines of code (LOC) produced [4] or to the inclusion of aspects related to the requirements, implementation, and validation [3]; (2) At the user level, it is possible to observe the degree of functionality achieved for the system, which is represented by the value delivered to the user [3], [4]; and (3) At the management level, it is focused on monetary aspects [3] and the teamwork performance [9].

All software companies need to measure their project productivity as this enables them to obtain indicators to manage and evaluate processes, projects, products, and people. The results of these measurements are used to make decisions and improve their software projects. Measuring productivity is used as a comparison tool for projects and developers [7]. Therefore, it provides work performance data for supporting the monitoring and controlling the process of software project management [2].

It is also suitable to improve decisions in software project management, define improvement strategies, and to reach high maturity levels in the organization leading to a more competitive company [6]. Besides, it is important to consider the productivity in the management of the software development project team, since the software product "is a direct product of the cognitive processes of individuals engaged in intellect-intensive, innovative teamwork" [2]. Thus, the team requires, in addition to technical skills, soft skills that promote team integration and cohesion. In this way, soft skills play an essential role in this process and can influence the productivity of the development team and project success [8].

In this context, Social and Human Factors (SHF) are of particular importance because they impact the results of software projects and are considered important elements affecting its costs [10], [11]. Failures in software projects may be related more to teamwork factors than to technical factors [12], [13]. Therefore, the study of SHF and their effect on software development productivity is in fact a matter of special interest for software companies [14] in view that personal aspects and human activities represent an opportunity to improve productivity [1].

This research aims at identifying, selecting, and defining productivity measures of software development associated with SHF. Our particular purpose is to establish a set of measures related to social and human factors that influence productivity in software development teams. Such measures are intended to help in the definition of improvement strategies with the inclusion of gamification initiatives [15]. In this case, the measures enable the evaluation of productivity strategies. These improvement strategies aim to stimulate SHF and analyze team productivity through the set of measures. To achieve it, it was necessary to distinguish from the set of measures found in the literature with those focused on the software development team and their management. Therefore, proposing strategies for software project management and productivity improvement may lead to more competitive software organizations [7]. In addition, addressing the difficulties related with SHF may help reduce software project management failures, improve team productivity, and even reduce both product cost and development time. For such purpose, a tertiary literature review was performed. Besides, the obtained measures were evaluated by a set of project management and productivity experts, the results of this evaluation enabling the selection of 13 productivity measures. Finally, the selected measures were related to SHF to get a set of productivity measures that influence software development productivity and therefore have a high impact on project management.

After the introduction, the article is organized as follows: Section 2 refers to studies related to the topics of interest in the software development area. Section 3 describes the methodological process followed to perform this research. Section 4 presents the results obtained from the tertiary literature review. Section 5 describes the selection process to evaluate the productivity measures. Section 6 states the definition of the selected measures and its comparison with SHF. Section 7 states the research threats, and finally, section 8 describes the conclusions and future work.

2. Related work

The study on software engineering productivity entails identifying factors that influence productivity and this involves defining related measures [7]. Influence factors are identified in the studies analyzed in this section, as well as productivity methods or models that are proposed from various work approaches. These studies focused on learning, modeling, and improving software development productivity, thus seeking to strengthen the development process benefiting the working team as well as the company.

Regarding the identification of factors that influence productivity, they have been classified based on different approaches, for instance, technical factors, organizational factors, product factors, and personal factors, among others. Wagner and Ruhe [16] presented in their literature review a set of productivity factors classified under technical factors and non-technical factors (*soft factors*). Oliveira et al. [17] performed a literature review and produced a list of factors classified as organizational factors, technical factors, and human factors.

Murphy-hill et al. [18] analyzed the productivity of developers in three organizations and identified that the prevailing factors were oriented toward non-technical factors, such as enthusiasm at work, colleagues supporting new ideas, and accepting valuable feedback regarding performance. Dias Canedo and Almeida Santos [19] researched those factors that affected software development productivity and open-source projects. Machuca-Villegas and Gasca-Hurtado [20] presented a classification of factors that influence software development productivity from a social and human perspective.

Regarding the measurement proposal and productivity models, Yilmaz [4] proposed a model based on social productivity and social capital. Hérnandez López [6] presented a productivity measure analysis in software development projects and proposes measuring at a job position level under a Data Envelopment Analysis (DEA) approach. De Oliveira Melo [21] describes a conceptual framework to study productivity in agile development teams.

Fatema and Sakib [22] created an agile teamwork productivity model with a Qualitative System Dynamics approach. The cause-effect relationship between productivity factors can help quantify and clarify the factor's influence to establish quantitative models.

Delaney and Schmidt [23] presented a literature review regarding the different approaches to measure and enhance software development productivity. They mention approaches oriented to quantify the number of outputs such as the function points or lines of code. They also mention approaches that compare the current effort with the estimated effort to produce outputs. This study reveals that the approaches described are oriented to specific scenarios rather than to a more general context. Likewise, Oliveira et al. [24] performed a systematic literature mapping to identify how productivity is being measured in the software development field. They discovered that the measurements are primarily used at the developer and software projects level. The prevailing measures are lines of code, time, and effort.

These studies highlight the importance of taking into account the social and human aspects of the work team. Consequently, recommendations and guidelines are suggested for project managers. However, they leave the door open for new researches on strategies that can be applied and validated easily in the context of software development teams and under the influence of SHF. Furthermore, these studies focus their attention on productivity measures, as they are important indicators for decision-making in software development team management and in the validation of new researches applied in this context. However, the number of measures related to the SHF may be limited because, in general, the measuring level is directed to the organization, the project, and the process. Thus, the interest in SHF within Software Engineering projects is still low [7].

In this context, this research is focused on finding productivity measures related to SHF that influence software development productivity [20], [25]. Of course, it should be taken into account that human factors or soft skills have a strong impact on the development team's productivity [21], IT project teams [8], and IT project complexity [26]. With this, we seek to contribute to the software engineering and software project management fields by proposing initiatives closely related to the working team [15]. We consider that the development process and its management is focused on people who play an important role in the results of the process performance.

3. Materials and methods

The process followed for the identification, selection, and definition of the measures related to SHF that influence software development productivity involves following three phases: (1) tertiary literature revision, (2) measure selection, and (3) measure comparison with SHF.

- Tertiary literature revision. Through the tertiary literature review, the productivity measures that are part of the objective of this research are obtained. The literature research was directed through the questions stated in Section 4.1. These questions allowed segmenting the review and contextualizing the results. In this phase, the list of the productivity measures associated with the context of this research is obtained (Table 2).
- Measure selection. Following this review, the process of selecting the productivity measures occurred. In this phase, it was necessary to rely on experts in organizational productivity and to define the selection criteria to review and evaluate the measures. The result of this phase is an evaluation report of the productivity measures (Table 3) and set of the productivity measures selected with their definition (Table 4).
- Measure comparison with SHF. The results of the measure selection indicate a low number of measures related to SHF. Therefore, it was necessary to make a measurement comparison with SHF. This final phase allowed proposing a possible relationship between productivity measures and the SHF. Its output is a list of productivity measures compared to SHF (Table 5).

Details and results of each of these phases are described in the following sections.

In order to conduct the tertiary literature review, the process adapted was the one proposed by Kitchenham [27], called Systematic Literature Review (SLR). A tertiary review is a systematic review performed based on secondary studies. The purpose of this review is to identify a set of productivity measures applied to the software development zprocess; those measures are specifically defined for the working team or the developers.

This review was conducted over a period extended from November 2019 to April 2020. The observation period of the selected studies was 2010 and 2019. The process and outcome of the review are described next.

3.1 Research questions

The following research questions are framed within the main research question: How is productivity measured about the social and human factors?

RQ1. Which productivity measures are used in software development? This research question aims to gather a set of productivity measures related to the research context.
RQ2. Which software engineering measurement level is associated with the productivity measure? This research question aims to identify measurement levels where the measures have been applied: this means in working teams or individuals.
RQ3. Do productivity measures include social or human factors? This research question aims to find measures related to the SHF that influence productivity. SHF were previously identified.
RQ4. How is the productivity measure defined? This research question aims to get acquainted with the variables that define the measure and facilitate their implementation in a certain context.

3.2 Search performed of secondary studies

The structure of the search string was proposed considering the topics that support the review. Such topics were software development, software development productivity, productivity measures, and literature reviews. Based on these topics, the following search string was set and executed:

("software engineering" OR "software development" OR "software maintenance" OR "software process") AND (productivity OR performance) AND (measure OR measurement OR measuring OR metric) AND (review OR overview OR literature OR meta-analysis OR "past studies" OR "in-depth survey" OR "subject matter expert" OR "analysis of research" OR "empirical body of knowledge" OR "overview of existing research" OR "body of published research" OR "mapping study" OR "systematic map")

The selected databases were ACM, IEEE, and Scopus. These scientific databases were selected according to the following criteria: (1) their relation with the computer science area; (2) their acknowledgment in the engineering field; and (3) the access available for the sponsors of the research.

The search results show a total number of 5003 studies (Table 1). The selection process described next is performed based on the results obtained.

3.3 Selection of studies

In order to obtain the primary studies, the following filters were defined: a) delete duplicates in each database; b) select studies using Microsoft Excel advanced filter option with search string keywords; c) delete duplicates after merging the three databases; d) title filter; e) abstract filter; f) content filter.

Moreover, together with the implementation of the filter, selection criteria were defined to implement it in the title, abstract, and content. Then, we present the defined criteria:

IC1. The study describes a literature review regarding productivity measures in software development.

IC2. The study follows a literature review process systematically or formally.

IC3. The study has been published in journals and conferences reviewed by peers.

The search and selection process is summarized in Table 1.

Table 1. The selection process for secondary studies

Database	Search Results	A	B	C	D	E	F
ACM	4103	2698	537		12	8	4
IEEE	491	491	96	**655**	6	3	1
Scopus	409	398	121		6	4	4
TOTAL	**5003**	**3587**	**754**		**24**	**15**	**9**

A) Delete duplicates in each database; B) Select studies using Microsoft Excel advanced filter option with search string keywords; C) Delete duplicates after merging the three databases; D) Title filter; E) Abstract filter; F) Content filter.

We reviewed 15 studies and selected nine studies closely related to the purpose of this research and the established selection criteria. Then, the tertiary literature review was conducted based on the following nine secondary reviews:

ID-1. Measuring Productivity in Agile Software Development Process: A Scoping Study (2015) [28]

ID-2. An Evolution of Software Metrics: A Review (2017) [29]

ID-3. Software Product Size Measurement Methods: A Systematic Mapping Study (2014) [30]

ID-4. A Systematic Mapping Study on Dynamic Metrics and Software Quality (2012) [31]

ID-5. Software Metrics Classification for Agile Scrum Process: A Literature Review (2018) [32]

ID-6. Methods for estimating agile software projects: A Systematic literature review (2018) [33]

ID-7. Software fault prediction metrics: A systematic literature review (2013) [34]

ID-8. Software engineering job productivity: A systematic review (2013) [35]

ID-9. Measuring and predicting software productivity: A systematic map and review (2011) [3]

3.4 Data Extraction

A Microsoft Excel template was used for data extraction, in which the information from the selected studies was consolidated. The information was divided into two sections: (1) *general data of the article*: Title, Author, Digital Object Identifier (DOI), Year, Keywords, and Abstract; and (2) *data related to research questions*: the objective of the systematic literature review, research question, productivity measures, definition of measures (metrics), measuring or abstraction level, mathematical approach, purpose, relationship with SHF.

During the data extraction, a mapping between the information of the selected studies and the required data was necessary to prepare this research. The steps taken to map each study are described below:

1. Article's general data registry; i.e., title, author, year, among others.
2. Article's comprehensive reading.
3. Extract data related to the questions created for this research. In those studies, where the data are implicit, the related information is inferred or the field is left empty. The extracted data are related to the measure, the abstraction, or measurement level, the purpose, and relationship with SHF (Table 2).
4. Data registry related to the research questions.

Taking into account the data of the consolidated studies, the following analysis was performed:

4. Results

The analysis is described based on the research questions posed. It is necessary to mention that some studies do not have information which is closely related to the research questions.

RQ1. Which productivity measures are used in software development?

The purpose of this question is to collect a set of productivity measures related to the context of this research. Table 2 shows a summary of the measures found in the review process. The selected studies provided literature review results regarding measurements, approaches, and methods or metrics of the software development process. Three of them bring forward a set of measures oriented to agile development [ID-1; ID-5; ID-6]. Some of these measures were used in traditional contexts as mentioned in Shah et al. [ID-1]. However, other studies consider these measures unsuitable in an agile context but keep adapting them to the process.

Some studies present measurement approaches that are aimed at organizing the measurement area of productivity concerning the different methods used. These approaches allow the grouping of measurement methods [ID-9]. The importance of this structure is highlighted because of its suitability for categorizing the selected measures.

Other studies describe the evolution of software measures, shifting from traditional methods to the aspect-oriented paradigm [ID-2]. This presentation of measures is related to the programming paradigm used. There also exist literature reviews oriented toward specific measures, such as the software product size [ID-3]; dynamic metrics [ID-4]; prediction metrics on software failures [ID-7]; and measures at a job position level [ID-8].

With the set of identified measures, it is possible to affirm that traditional measures are still being used, such as LOC and the function points (FP). Likewise, an evolution of the measures applied can be observed in the agile context. From the reports submitted in 2015 by Shah et al. [ID-1] to the ones described in 2018 by Kurnia et al. [ID-5] and Canedo et al. [ID-6], a new set of specific contextual measures are taken, even though traditional measures are still being reported [ID-6]. Additionally, it is stated that in the last three years, the mentioned studies foresee their results toward agile development [ID-5] and [ID-6]; this points out the trend of this new work approach in software development processes.

Those productivity measures, which are oriented towards research contexts other than to the purpose of this study were excluded, such as software dynamic metrics which try to measure features when executing the software, for instance, dynamic dependencies between components [ID-4] or either prediction metrics on software failures [ID-7].

Table 2. Summary of productivity measures

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
ID-1 [28]	Lines of executable code/staff day [28]	Team	Evaluation	---
	Lines of code/person-hour [28]	Team	Evaluation	---
	Lines of code/hours [28]	Team	Evaluation	---
	Lines of code [28]	Team	Evaluation	---
	Average number of unadjusted function points completed per unit of time [28]	Team	Evaluation	---
	Resolved issues/month [28]	Per developer	Evaluation	---
	Functional size/effort [28]	Team (scrum)	Evaluation	---
	Function points/months [28]	Per developer	Evaluation	---
	Function Points/staff month [28]	Team	Evaluation	---
ID-2 [29]	**TRADITIONAL FUNCTION - ORIENTED METRICS**			
	Size Metrics: Lines Of Code (LOC): LOC/man-month [29].	Product	Estimation Evaluation	---
	Token Count: "These symbols are called tokens. The basic measures are: n1 = count of unique operators n2 = count of unique operands N1 = count of total occurrences of operators N2 = count of total occurrence of operands In terms of the total tokens used, the size of the program can be expressed as N = N1 + N2" [29]			
	Software Science Metrics: Halstead's model [29]	Product	Estimation Evaluation	---
	McCabe's Cyclomatic Metric [29]	Product	Estimation Evaluation	---
	OBJECT - ORIENTED METRICS			
	Chidamber and Kemerer's Metrics Suite [29]: - Weighted Methods per Class (WMC) [29] - Response for a Class (RFC) [29] - Lack of Cohesion of Methods (LCOM) [29] - Coupling between Object Classes (CBO) [29] - Depth of Inheritance Tree (DIT) [29] - Number of Children (NOC) [29]	Product	Evaluation	---
	MOOD'S Metrics for Object-Oriented Design [29]**:** - Method Hiding Factor (MHF) [29] - Attribute Hiding Factor (AHF) [29] - Method Inheritance Factor (MIF) [29] - Attribute Inheritance Factor (AIF) [29] - Polymorphism Factor (PF) [29] - Coupling Factor (CF) [29]	Product	Evaluation	---
	COMPONENT-ORIENTED METRICS			---
	- Average Interaction Density (AID) [29] -Incoming Interaction Density (IID) [29] - Outgoing Interaction Density (OID) [29]	Product	Evaluation	---
	ASPECT-BASED METRICS			---
	- Number of Aspects [29] - Number of Pointcuts per Aspect [29]	Product	Evaluation	---

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
	- Number of Advices per Aspect [29] - Degree of Crosscutting per Pointcut [29] - Response for Advice [29]			
ID-3 [29]	**See Appendix A.**	Product	Estimation	---
ID-4 [30]	**Dynamic Metrics:** - Coupling [30] - Cohesion [30] - Complexity [30] - Method invocation [30] - Polymorphism [30] - Memory-related [30] - Code coverage [30] - Size/Structure [30]	Product	Evaluation	---
ID-5 [32]	**SPRINT PLANNING METRICS [32]:** - Effort estimate [32] - Story point [32] - Task effort [32] - Task's expected and end date [32] - Velocity [32]	Process Project Team	Estimation Evaluation	---
	DAILY SPRINT METRICS [32]**:** - # of an open defect [32] - Contribution [32] - The ratio of work spent and work remaining [32] - Standard violation [32] - The release burndown chart [32] - The sprint burndown chart [32]	Process Project Team-Individuals		Contribution
	SPRINT REVIEW METRICS [32]**:** - # of defects found in system test [32] - Bug correction time from new to the close state [32] - Business value delivered [32] - Customer satisfaction [32] - Completed web pages [32] - Defects deferred [32] - Defects per iteration [32] - Delivery on time [32] - Error density [32] - Focus factor [32] - Fulfillment of scope [32] - Number of stories [32] - Open defect severity index [32] - Percentage of Adopted work [32] - Percentage of Found work [32] - Progress chart (Scrum board) [32] - Unit test coverage for developed code [32] - Work capacity [32]	Process Project Team		Customer satisfaction
	SPRINT RETROSPECTIVE METRICS [32]**:** - Earn value management (EVM) [32] - Impression [32] - Influence [32] - Job satisfaction [32] - Net promoter score [32]	Process Project Team		-Impression -Influence -Job satisfaction -Net promoter score
ID-6	- Story Point [33]	Product (size) Project	Estimation	-Expert Opinion

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
[33]	- Point of Function [33] - Expert Opinion [33] - Estimate based on model (COCOMO) [33] - Planning Poker [33] - Use-Case Points [33] - Custom Templates [33] - Number of Lines of Code [33] - Fuzzy based Framework for Estimation [33]			
ID-7 [34]	**See Appendix B**	Product	Prediction	---
ID-8 [35]	**Tasks/Time:** - Milestones/m [35] - (Completed program)/h [35] - (Completed tasks)/h [35] **LOC/Time:** - SLOC/h [35] - NCSS/h (No commentary Source Statement) [35]	Job position	Estimation	---
ID-9 [3]	**Measurement-based analytical models [3]:** - Weighted productivity factors [3] - Simple Input/Output Ratios [3] - Data envelopment analysis [3] - Bayesian belief networks [3] - Earned value analysis [3] - Statistical process control [3] - Balanced scorecard [3] - Metric space [3]	Project Individual Tasks Organization	Predictive Measurement Reactive Measurement	---
	Dynamic software development models [3]: - Continuous simulation [3] - Event-based simulation [3] - Hybrid simulation [3]	Project Individual Process	Predictive Measurement	---

RQ2. Which measurement level is associated with the productivity measure?

The point of this question is to identify measurement levels, i.e., in the working team or individuals where the measures have been applied. The measurement level refers, for example, to a project, module, process, developer, or tasks, among others [7]; it may also represent the analysis unit. The purpose is to analyze the measurement level to identify measures that are compatible with the team or the individual's productivity.

In connection with the above, measures related to the project, product, process, individual, tasks, organization, team, size, developer, and job position were found (See Table 2). The measures associated with the product, project, and software process prevail compared with those measures focused on the developer or on the working team, which appear on a smaller scale.

RQ3. Do productivity measures include social or human factors?

The purpose of this question is to find productivity measures that enable a relation with SHF that influence productivity in software development teams [20], [25]. The results show that a low number of measures fulfill these features. Instead, there is a trend toward a product and software process-oriented measurement. In Kurnia et al. [ID-5] and Canedo et al. [ID-6], a possible relationship with SHF was observed. The measures suggested in these studies are

intended for agile software processes. This leads to the conclusion that agile methodologies promote the development of SHF in software processes. The following measures were identified:

- Contribution: Evaluate the direct participation and the level of compromise during the daily Scrum meeting [32].
- Customer satisfaction: A quantitative evaluation of customers' satisfaction based on certain parameters [32].
- Impression: Review each team members' work based on the other team member's opinions [32].
- Influence: Measures individuals' engagement and participation in the project's progress [32].
- Job satisfaction: Developer's personal satisfaction with his work [32].
- Net promoter score: Measures customers' satisfaction and its impact. Customers' satisfaction enables them to recommend products to other potential customers [32].
- Fulfillment of scope: Shows how the team fulfills with the agreed terms in sprint planning [32].
- Expert opinion: Effort estimation technique in an agile context [33].

Six out of the eight measures defined above are related to SHF, which were already classified in previous studies Machuca-Villegas and Gasca-Hurtado [20], Machuca-Villegas et al. [25]. However, the other two measures (Customer Satisfaction and Net promoter score) are not related to such factors. The relationship between the six measures and the SHF is presented below:

1. Relationship between Contribution measure and SHF Commitment, Collaboration, Communication, Team cohesion.
2. Relationship between Impression measure and SHF Team cohesion, Autonomy.
3. Relationship between Influence measure and SHF Commitment, Collaboration, Communication, Team cohesion.
4. Relationship between Job satisfaction measure and SHF Motivation, work satisfaction.
5. Relationship between Fulfillment of scope measure and SHF Commitment.
6. Relationship between Expert Opinion measure and SHF Capabilities and Experiences in software development process, Capabilities, and Experiences in software project management.

RQ4. How is the productivity measure defined?

The purpose of this question is to find the defining variables that make its implementation easier in a certain context. The studies that present productivity measures in line with this research are [ID-5], [ID-6], and [ID-8]. Other studies were excluded since they were out of the scope of this research, either because the measures are included in the selected studies or because they represent generic approaches or highly complex quantitative approaches. A set of 48 potential measures was obtained from these three studies. It was necessary to conduct an evaluation and selection process for each of the measures. This process is described in the following section. The definition of the selected measures is stated in Section 6.

5. Selection of productivity measures

When searching the measures related to SHF that influence productivity in software development, a low number of measures that fulfill this requirement were found (RQ3). *Soft-factors* are difficult to measure [21]. Therefore, the scope of this search needs to expand toward measures that are in line with this research in such a way that: (1) they can be adapted to different contexts of software development; (2) they can be used to evaluate rather than to estimate; (3) they can be applied in development teams; and (4) they can be easily applied. These selection requirements are summarized in the criteria shown below:

- Generality: Measure suitable for various contexts, searching generality.
- Purpose: A measure in software may be used to estimate or evaluate. In this particular project, it is expected that the measure is used to evaluate rather than to estimate.
- Abstraction or measurement level: The measure can be applied in software development teams.
- A measure easy to define: A measure, which is easy to calculate. Its inputs and outputs can be easily obtained.

Besides understanding the definition of selection criteria, this selection process included an evaluation of each of the identified measures. The evaluation process included using a binary evaluation measurement for each criterion, where "1" is assigned when the measure meets the criterion and "0" when it does not. Four researchers were selected for this evaluation (two experts in organizational productivity, and two internal researchers from the project sponsoring this research). This group of researchers will be called the focus group. The focus group conducted an individual evaluation process of the measures according to the established criteria.

Table 3 shows the grade assigned by each focus group researcher and the evaluation regarding the fulfillment criteria. In this table, evaluation 1 shows the fulfillment of the four criteria assigned by each expert. While evaluation 2 shows those measures that at least meet three criteria assigned by each expert. Evaluation 2 was necessary given the low number of measures obtained in evaluation 1.

Table 3. Evaluation Report of the productivity measures

Measure	Researcher 1				Researcher 2				Productivity Expert 1				Productivity Expert 2				Evaluation - 1	Evaluation - 2
	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4		
- Effort estimate [32]	0	0	1	1	1	0	0	1	1	0	1	0	0	1	1	0	NO	NO
- Story point [32]	1	0	1	1	1	0	0	1	0	0	1	0	0	0	1	0	NO	NO
- Task effort [32]	1	0	1	1	1	0	0	1	1	0	1	0	0	0	1	0	NO	NO
- Task's expected and end date [32]	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	NO	NO
- Velocity [32]	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	NO	YES
- # of an open defect	0	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	NO	NO
- Contribution [32]	0	1	1	1	1	1	1	0	0	1	1	1	0	1	1	0	NO	NO
- The ratio of work spent and work remaining [32]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	YES	YES
- Standard violation [32]	0	0	1	0	1	1	1	1	0	1	1	1	0	1	1	0	NO	NO
- The release burndown chart [32]	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	NO	YES
- The sprint burndown chart [32]	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1	NO	YES
- # of defects found in system test [32]	0	1	1	0	1	1	0	1	0	1	1	1	1	1	1	1	NO	NO
- Bug correction time from new to the close state [32]	0	1	1	0	1	1	0	0	1	0	1	0	1	0	1	1	NO	NO
- Business value delivered [32]	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	NO	NO
- Customer satisfaction [32]	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	NO	NO
- Completed web pages [32]	0	0	1	0	0	1	1	1	0	1	1	1	0	0	1	1	NO	NO
- Defects deferred [32]	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1	NO	NO
- Defect per iteration [32]	-	-	-	-	1	1	0	1	0	1	1	0	0	1	1	0	NO	NO
- Delivery on time [32]	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	NO	YES
- Error density [32]	0	1	1	1	0	1	0	0	0	1	1	1	0	1	1	1	NO	NO
- Focus factor [32]	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	NO	NO
- Fulfillment of scope [32]	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	NO	YES
- Number of stories [32]	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	NO	YES
- Open defect severity index [32]	0	0	1	1	0	1	0	0	0	1	1	0	0	1	1	0	NO	NO
- Percentage of Adopted work [32]	0	0	1	1	1	1	0	1	0	1	1	1	0	1	1	1	NO	NO
- Percentage of Found work [32]	1	0	1	1	1	1	0	1	0	1	1	0	0	1	1	0	NO	NO
- Progress chart (Scrum board) [32]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	YES	YES
- Unit test coverage for developed code [32]	0	0	1	1	1	1	0	1	0	1	1	1	0	1	1	1	NO	NO
- Work capacity [32]	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	NO	NO
- Earn value management (EVM) [32]	0	1	1	0	1	1	0	0	1	1	1	1	1	1	1	1	NO	NO
- Impression [32]	1	0	1	0	1	1	1	1	1	0	0	0	1	0	1	1	NO	NO
- Influence [32]	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	NO	YES
- Job satisfaction [32]	1	0	1	0	1	1	1	1	1	1	1	1	1	0	1	1	NO	YES
- Net promoter score [32]	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	NO	YES
- Story Point [33]	1	0	1	1	1	0	0	1	1	0	1	0	1	0	1	1	NO	NO
- Point of Function [33]	0	0	1	0	1	0	0	0	0	1	0	1	0	1	1	0	NO	NO
- Expert Opinion [33]	1	0	1	0	1	0	0	1	1	0	1	1	1	0	1	1	NO	NO
- Estimate based on model (COCOMO) [33]	0	0	1	0	1	0	0	0	0	1	0	1	0	1	1	0	NO	NO

Measure	Researcher 1				Researcher 2				Productivity Expert 1				Productivity Expert 2				Evaluation - 1	Evaluation - 2
	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4	SCPM -1	SCPM -2	SCPM -3	SCPM -4		
- Planning Poker [33]	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**NO**	**NO**
- Use-Case Points (UCP) [33]	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**NO**	**NO**
- Custom Templates [33]	-	-	-	-	-	-	-	-	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**NO**	**NO**
- Number of Lines of Code [33]	-	-	-	-	**1**	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**NO**	**NO**
- Fuzzy based Framework for Estimation [33]	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**NO**	**NO**
- Milestones/m [34]	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**NO**	**YES**
- (Completed program)/h [34]	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**NO**	**YES**
- (Completed tasks)/h [34]	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**NO**	**YES**
- SLOC/h [34]	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	-	-	-	-	**NO**	**NO**
- NCSS/h (Non-commentary Source Statement) [34]	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	-	-	-	-	**NO**	**NO**

Two measures meet all the criteria: the ratio of work spent and work remaining, and the progress chart (Scrum board) (See column Evaluation 1 – Table 3). While 13 measures meet at least three criteria, including the two formerly mentioned (see column Evaluation 2 – Table 3). These are velocity, the ratio of work spent, and work remaining, the release burndown chart, the sprint burndown chart, delivery on time, fulfillment of scope, number of stories, progress chart (Scrum board), influence, net promoter score, milestones/m, (completed program)/h, (completed tasks)/h.
The set of measures with its corresponding definitions is presented below. The measures defined are those that fulfill the three selection criteria, so these answers RQ4. Table 4 provides the definition of the selected measures.

6. Productivity measures for software development influenced by SHF

The set of software development productivity measures related to SHF is represented by the measures selected from the tertiary literature review, and the evaluation conducted by the focus group. This set of measures contains two measures close to the SHF identified in Machuca-Villegas et al. [25] and 11 measures in line with this research, though these 11 measures have a weak relationship with SHF. This allows establishing the proposed set of measures.

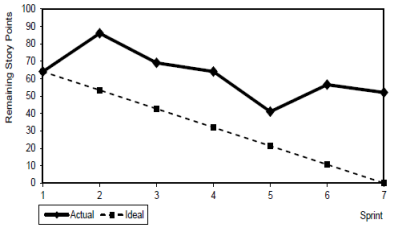
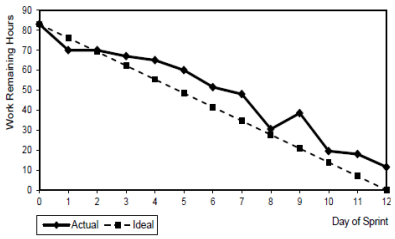
The purpose of this research is limited to identify productivity influencing factors of software development to produce improvement strategies. Therefore, the aim is to evaluate the results of such strategies by measuring productivity with the measures detailed in the literature, especially, those measures associated with the development team level rather than evaluating SHF themselves.

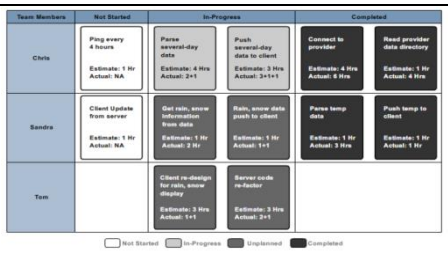
6.1 Definition of the measures

Table 4 provides the definition of the selected measures.

Table 4. Set of the productivity measures selected

Name	Description	Measure
Velocity [ID-5] [36]	The number of work completed during the sprint. A measure used to calculate team productivity during the sprint. Besides, "it is used as a reference to forecast the amount of work that can be completed in the next sprint and estimate the number of sprints required to complete the project" [32].	$\sum$ *all work accepted*
The ratio of work spent and work remaining	"The ratio between the number of completed tasks (per day), and the remaining task (per day)" [32].	Work spent on day *i* for each task *j* in the sprint backlog – *Wsij* [32]

Name	Description	Measure
[ID-5] [37]	"The objective value is 1 or less, which means that the amount of work remaining decreases proportionally to the amount of work spent" [37].	Remaining work on day *i* for each task *j* in the sprint backlog – *Wrij* [32] $\frac{\sum_{i=d1}^{d2-1}\sum_{j=1}^{n} WS_{i,j}}{\sum_{j=1}^{n} WR_{d1,j} - \sum_{j=1}^{n} WR_{d2,j}}$
The release burndown chart [ID-5] [38]	Represents the amount of remaining work, and its decrease for each sprint keeping track of the sum of each story point to all incomplete stories in the Product Backlog [38]. Indicates team performance during the development process. This metric is aimed at monitoring the entire project, and the activities performed by the team [38].	A chart to describe the project's progress (ideal progress vs. real progress) based on the remaining tasks in a time framework (sprint). 
The sprint burndown chart [ID-5] [38]	Represents the amount of remaining work that must be completed until the end of the Sprint [32] [38]. Indicates the team's performance during the development process. This metric is aimed at monitoring the entire project and the activities performed by the team [32] [38]. It is used to monitor the project's progress based on total work, and remaining sprints duration [32] [38].	A graphic that represents the work to be done in the sprint and if the teams are planned. 
Delivery on time [ID-5] [39]	Indicates if the scope is being managed and understood [32] [39]. It is useful for tracking and predicting the project's progress [32][39]. The outcome is the customer's real value when delivering the features performed [32][39].	The features proportion is made on the planned delivery schedule.
Fulfillment of scope [ID-5] [37]	Shows how the team complies with the agreed commitments under the sprint planning [32] [37]. The objective value is 1. This means that the agreed commitments at the beginning of the Sprint or release were fulfilled [32][37].	Implemented #PBI / planned #PBI #Completed tasks / # Sprint Backlog tasks #Completed tasks during the sprint
Number of stories [ID-5] [40]	Project process tracking based on the number of accepted stories [40] . "This metric is calculated as a simple count or weighing due to the story complexity, as simple, medium, and complex, regarding the number of stories in the sprint" [40].	PBI (Product Backlog Item) # Developed and accepted stories

Name	Description	Measure
Progress chart (Scrum board) [ID-5] [40]	A tool to track the team member's progress. This shows the project's progress according to the status of the task (not started, in progress, and completed) in the chart [32]. It is useful for: - Comparing the current project status vs. the estimated status - Check if the team member's workload is balanced as to the number of hours and tasks. - Quickly check the project's progress [40].	
Influence [ID-5] [41]	Measures the individual's participation and commitment within the project's progress [32]. This activity can be in the form of information or as an intellectual and creative vision, production results, and project's general communication and team management [40].	Average (individual events per day) / Average (total events of the team per day) [26].
Net promoter score [ID-5] [42]	Measures customer's satisfaction and obtain feedback through a qualitative survey [32][42].	Qualitative survey
Milestones per minute [ID-8]	A measure used to evaluate the project's progress or team/developer performance [35].	Milestones/m Minutes (m)
Programs completed per hour [ID-8]	A measure used to evaluate the project's progress or team/developer performance [35].	(Complete programs)/h Hours (h)
Completed tasks per hour [ID-8]	A measure used to evaluate the project's progress or team/developer performance [35].	(Complete tasks)/h Hours (h) Difficulty and effort may also be taken into account.

6.2 Comparison of the measures selected with SHF

From the selected productivity measures, 11 do not reveal a relationship with SHF that influence productivity in software development. However, a comparison can be made between these measures and the definitions of SHF expressed in Machuca-Villegas et al. [25] to find a relationship between them. To such end, SHF were analyzed as factors influencing professional's productivity in a transversal manner to the software development process. Thus, in this relationship, the SHF is perceived as an implicit and underlying aspect of the individual, impacting his/her behavior, and, consequently, his/her productivity. Therefore, it is possible to identify an implicit relationship between the SHF with the selected productivity measures. This identified relationship is presented in Table 5.

The comparison process was conducted under the following steps:

1. Reviewing each of the productivity measures definitions described in Table 4.
2. Reviewing each of the SHF definitions described in Machuca-Villegas et al. [25].
3. Mapping and finding the relationship between the productivity measure and SHF according to each factor definition.
4. Justification of the established relationship. A productivity measure may be related to more than one SHF.
5. Having the comparison reviewed by a more experienced researcher.

The results of this comparison indicate that one of the SHF more closely related to these measures is "commitment". This reveals the importance of committing to doing the necessary tasks to obtain a successful project in line with the objectives set. On the other hand, in those measures associated with the team's performance, it was possible to identify a

close relationship with the SHF of "collaboration", "team cohesion", capabilities, and experiences in the software development process. These factors represent the need to conduct integrated teamwork.

Table 5. Comparison of measures and SHF

SHF	Measure	Comparison Justification
Commitment	• Velocity [ID-5] [36] • The ratio of work spent and work remaining [ID-5] [37] • Delivery on time [ID-5] [39] • Fulfillment of scope [ID-5] [37] • Number of stories [ID-5] [40] • Progress chart (Scrum board) [ID-5] [40] • Influence [ID-5] [41] • Milestones per minute [ID-8] • Programs completed per Hour [ID-8] • Task completed per hour [ID-8]	The team should carry out the necessary tasks to obtain a successful project in line with the objectives set. The progress and goal's achievement shall be communicated timely to team members.
Motivation	• Velocity [ID-5] [36] • The ratio of work spent and work remaining [ID-5] [37] • Influence [ID-5] [41]	Team members shall feel that the tasks they perform are valuable to achieve the objectives. Intrinsic motivation means doing something because it is enjoyable and important.
Collaboration	▪ The release burndown chart [ID-5] [38] ▪ The sprint burndown chart [ID-5] [38] ▪ Influence [ID-5] [41] ▪ Milestones per minute [ID-8] ▪ Programs completed per Hour [ID-8] ▪ Task completed per hour [ID-8]	Team members shall work collaboratively to reach project goals. Team members shall be willing to assist, support, and encourage their colleagues.
Team Cohesion	▪ The release burndown chart [ID-5] [38] ▪ Progress chart (Scrum board) [ID-5] [40] ▪ Influence [ID-5] [41] ▪ Milestones per minute [ID-8] ▪ Programs completed per Hour [ID-8] ▪ Task completed per hour [ID-8]	Team members need to work at similar rates. Activities should be executed on time and all responsible parties shall participate. It is important that members feel identified with the team in which they participate in a voluntary and motivated manner. Each team member shall enjoy performing tasks with their colleagues.
Capabilities and experiences in software development process.	▪ The release burndown chart [ID-5] [38] ▪ Milestones per minute [ID-8] ▪ Programs completed per Hour [ID-8] ▪ Task completed per hour [ID-8]	The team shall know the subject or have experience working in similar contexts. The team shall have knowledge or experience with the tools and programming language necessary for the project. Team members must have the ability to implement efficient solutions to meet the project's requirements.
Team Cohesion	▪ The sprint burndown chart [ID-5] [38]	Team members need to work at similar rates. Activities must be executed on time and all responsible parties shall participate.

SHF	Measure	Comparison Justification
Capabilities and experiences in software development process	▪ The sprint burndown chart [ID-5] [38]	The team shall know the subject or have experience working in similar contexts. The team shall have knowledge or experience with the tools and programming language necessary for the project. Team members must have the ability to implement efficient solutions to meet the project's requirements.
Communication	▪ Delivery on time [ID-5] [39] ▪ Influence [ID-5] [41]	The project's goals and activities involved should be clearly and expressly communicated to all project participants. Communication among team members is very important support.
Job satisfaction	▪ Progress chart (Scrum board) [ID-5] [40]	Team members shall be satisfied with the equal distribution of the tasks.
Not applicable	▪ Net promoter score [ID-5] [42]	SHF influence the team's productivity; the relationship with the client has not been taken into account.

7. Threat to the validity of the results

It is important to take into account the threats to the validity of the results of all research studies. Particularly in this research, among the identified threats are those related to the generalization of the results, lack of details in the studies analyzed, the researcher's bias, and the limitation regarding the number of measures closely related to SHF.

The generalization of the results is restricted to some secondary studies selected in the tertiary literature review. The search strategy used could have omitted collecting some relevant articles that have an impact on the results. Therefore, three databases were used—all of scientific nature and specialized in computer science. Likewise, the selection of studies was led by the inclusion criteria involved in the research questions defined for this investigation.

The lack of details in the analyzed studies could have influenced the interpretation of the results, especially when selecting the productivity measures. In some cases, it was necessary to resort to a primary source to ease the definition of the selected measures.

The researcher's bias is another frequent threat found in the investigation. In this research, bias is exposed in the process of the tertiary literature review, in the measure selection process, and the process regarding the comparison of the selected measures with SHF. In order to mitigate this threat, the following was considered:

- The support of a more experienced researcher to accomplish the tertiary review protocol.
- The experience of experts on organizational productivity (focus group) to assess the selection criteria of the productivity measures.
- Having the comparison results reviewed by a more experienced researcher.
- Having a third researcher as a reviewer for the entire process and the results obtained.

To conclude, the limited number of measures associated with SHF risked the research outcomes. However, the selection of new criteria was proposed to obtain measures in line with the research context. Moreover, a comparison between the selected measures and SHF was proposed to suggest possible relationships between them.

8. Conclusion and future work

Software companies need to obtain indicators to manage and evaluate processes, projects, products, and people involved. Indicators are used to make decisions, manage projects, and improve processes. In most cases, the indicators are related to productivity measures. In software development companies, these indicators are used as a comparison tool between projects and developers to define improvement strategies and make decisions to manage software projects.

In this research, a set of productivity measures in software development is presented, and defined based on the results of a tertiary literature review and an evaluation process performed by project management and productivity experts. As result, a set of 13 measures were identified. These measures become a basis for assessing the software development teams' management and the results of productivity improvement strategies when SHF are introduced within these teams.

The results of this comparison indicate that one of the SHF more closely related to these measures is "commitment". This reveals the importance of committing to doing the necessary tasks to obtain a successful project in line with the objectives set. These results are in line with the results obtained from the study performed by Cunha De Oliveira [7] which revealed that software managers and project leaders consider that the commitment factor is essential to obtain a successful project. On the other hand, in those measures associated with the team's performance, it was possible to identify a close relationship with the SHF of "collaboration", "team cohesion", "capabilities, and experiences in the software development process". These factors represent the need to conduct integrated teamwork as the success of a project also depends on how professionals perform their tasks and the way they interact with their team. The above ratifies Capretz and Ahmed's thoughts [43] which promote the importance of soft skills in the field of Software Engineering in the performance of professionals.

The tertiary review helped to identify that traditional measures such as LOC and FP are still being used. Although Hernadez López [6] indicated that these measures help to assess the project delivery efficiency, they still do not reflect the work team's activities in such a way as to facilitate their relationship with the SHF. Similarly, new measure proposals applied in the agile context were identified. In this context, productivity measures can be more related to the SHF [28] and, therefore, they turn out to be key measures for the work team. Software dynamic metrics were also identified, which focus on executing software and the prediction measures related to software failures.

The abstraction level of the identified measures was associated with the project, product, process, individuals, tasks, organizations, team, size, developer, and job position. The levels associated with the product, project, and software process prevail while the levels focused on the developer, or the working team appears on a smaller scale. These results show a constant in the use of traditional productivity measures and, as expressed by Cunha De Oliveira [7] the SHF are gaining importance in the management of software projects.

The secondary studies related to agile methods present measures associated with SHF, which confirm that agile methodologies improve the SHF development in the software projects. This is related to the Agile Manifesto which highlights the importance of individuals and interactions over processes and tools (https://agilemanifesto.org/). In this research, 76.92% of the measures identified are included in the context of Agile development.

Moreover, it was possible to compare the obtained set of 13 measures and the SHF. Through such comparison, a preliminary approach between *soft factors* and productivity measures is proposed, of course having into account that these factors are not easy to measure [21] and that measuring them is out of this research scope.

Since SHF were included in the performance of work teams, this research support in understanding the area of knowledge associated with software development and project management processes. This allows establishing a set of useful management and decision-taking measures based on concrete measurement indicators. The understanding of this knowledge area based on a set of measures, such as those identified in this research, provides support for designing improvement strategies and sets productivity indicators which are important for software development projects.

The main research findings facilitate working on new proposals within this context. Some of these proposals can be geared toward the following future works:

- Inclusion of a set of 13 measures to a model based on gamification and SHF to influence in software development productivity. Based on this set of measures, it will be possible to have indicators to analyse how the model influences on the productivity of the development team.
- Design of improvement strategies. The main goal is to focus these strategies on the management of software development projects beginning with the measures set identified. Such a set of measures is an essential input to design strategies focused on the encouragement of SHF supported in gamification.
- Design of quasi experiment to analyze the impact of the measures in the improvement strategies applied.
- Creation of a Simulation system based on system dynamics to study the relationship between the identified measures and the SHF.
- Broaden the search for productivity measures to identify those that facilitate a general measurement of both teams and individuals may be necessary.

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Appendix A. Summary of productivity measures [ID-3]

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
ID-3 [30]	Albrecht/IFPUG FPA MK II FPA Project Size Unit Size as a Vector The mini model method Use Case Size Point Estimate (estimate size and effort) Full Function Points (FFP) COSMIC RmFFP COSMIC like model for Web Based Appl. Object Oriented Method CFP (OOmCFP) Model for size estimation from S-BPM Data Mart Size Measurement Improved FPA (Fuzzy Rules and BP Network) Fuzzified FPA Object Oriented Hypermedia Function Point Requirement Points Updating OOmFP OOmFP Object Oriented Method FP for WEB (OOmFPWeb) COSMIC with PRiM Non-Functional Req. Size Measurement Method Cloud Migration Point Method Multi Granularity OO Est. Model Fuzzy Size Estimation Procedure Class Point Extension Class Point Component Point UCP Fuzzy Logic Model to Approximate Size UML based COSMIC COSMIC to Problem Frames Approximate COSMIC FP using Text Mining E-COSMIC UML based COSMIC Functional Size of Interactive Sys. FAST FSM Refined FSM for Embedded System (Simulink) FSM for Embedded System (Req. expressed as Simulink Guidelines to measure size in the context of Autostar Fine grain measurement for UML use case diagram Early and Quick Estimation Technique for COSMIC COSMIC for Real Time OO Modeling Lang. (ROOM) COSMIC from Business Process Model Method to estimate size for CAL system Software Size Model Rapid FPA A refined method to measure UML Model Object Oriented Function Point Simplified IFPUG Object Oriented Design Function Point NESMA	Product	Estimation	---

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
	A size estimation method Estimating size of Formal Comm. Protocol Specification Database Size (No. of Entities, No. of Screens) Method to measure database size Database Size Estimation Based on ER (DSER) Probabilistic Size Neural Network for size estimation No. of Test Cases for system size SLOC estimation from Conceptual data model Estimation of test suite size from test case number SLOC Estimation from UML Class Diagram Component Size Estimation Refined Predicting Object Point (PoP) Fuzzy Function Point Analysis (FFPA) Counting rules for MK II FP in SSAD Environment A generalization of FP Size Estimation Method Measurement of amount of Information MTPF FP Measure Method Bottom Up Software Size Estimation Bottom up and top down approaches of FPA			

Appendix B. Summary of productivity measures [ID-7]

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
ID-7 [34]	AHF - Attribute Hiding Factor AIF - Attribute Inheritance Factor COF - Coupling Factor MHF - Method Hiding Factor MIF - Method Interface Factor POF - Polymorphism Factor SCC - Similarity-based Class Cohesion ANA - Avgrage Number of Ancestors CAM - Cohesion Among Methods CIS - Class Interface Size DAM - Data Accesss Metric DCC - Direct Class Coupling DSC - Design size in classes MFA - Measure of Functional Abstraction MOA - Measure of Aggregation NOH - Number of hierarchies NOM - Number of Methods NOP - Number of polymorphic methods LCC - Loose class cohesion TCC - Tight class cohesion ACAIC ACMIC AMMIC Coh - A variation on LCOM5 DCAEC	Product	Prediction	---

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
	DCMEC			
	DMMEC			
	FCAEC			
	FCMEC			
	FMMEC			
	IFCAIC			
	IFCMIC			
	IFMMIC			
	OCAEC			
	OCAIC			
	OCMEC			
	OCMIC			
	OMMEC			
	OMMIC			
	ATTRIB - Attributes			
	DELS - Deletes			
	EVNT - Events			
	READS - Reads			
	RWD - Read/write/deletes			
	STATES - States			
	WRITES - Writes			
	CBO - Coupling between object classes			
	DIT - Depth of inheritance tree			
	LCOM - Lack of cohesion in methods			
	LCOM2 - Lack of cohesion in methods			
	NOC - Number of children			
	NTM - Number of trivial methods			
	RFC - Response for a class			
	WMC - Weighted methods per class			
	AMC - Average method complexity			
	Past faults - Number of past faults			
	Changes - Number of times a module has been changed			
	Age - Age of a module			
	Organization - Organization			
	Change set - Number of modules changed together with the module			
	N1 - Total number of operators			
	N2 - Total number of operands			
	η1 - Number of unique operators			
	η2 - Number of unique operands			
	AID - Average inheritance depth of a class			
	LCOM1 - Lack of cohesion in methods			
	LCOM5 - Lack of cohesion in methods			
	Co - Connectivity			
	LCOM3 - Lack of cohesion in methods			
	LCOM4 - Lack of cohesion in methods			
	ICH - Information-flow-based cohesion			
	ICP - Information-flow-based coupling			
	IH-ICP - Information-flow-based inheritance coupling			
	NIH-ICP - Information-flow-based non-inheritance coupling			
	CMC - Class method complexity			
	CTA - Coupling through abstract data type			
	CTM - Coupling through message passing			
	NAC - Number of ancestor			
	NDC - Number of descendent			
	NLM - Number of local methods			
	DAC - Data abstraction coupling			

Studies	Measure / Metric / Approach / Method	Abstraction or Measurement level	Purpose	Relationship with SHF
	DAC1 - Data abstraction coupling MPC - Message passing coupling NCM - Number of class methods NIM - Number of instance methods NMA - Number of methods added NMI - Number of methods inherited NMO - Number of methods overridden NOA - Number of attributes NOAM - Number of added methods NOO - Number of operations NOOM - Number of overridden methods NOP - Number of parents NPAVG - Average number of parameters per method SIX - Specialization index C3 - Conceptual cohesion of Classes CC - McCabe's Cyclomatic Complexity Delta - Code delta Churn - Code churn Change request - Change request Developer - Number of developers CLD - Class-to-leaf depth NOA - Number of ancestors NOD - Number of descendants LOC - Lines of Code			

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Abstract:
Digital transformation projects will become one of the dominating tools for mastering digital transformation in governments. Studies show that such projects are complex undertakings and increasingly difficult to manage. The purpose of the paper is to provide a better understanding of the factors that cause complexity in government digital transformation projects. The authors use an in-depth case study approach to investigate factors of complexity in an ongoing digital transformation project. The results indicate that complexity in this project is rooted in dynamic relationships between multiple dimensions of organization, technologies, and innovation. The authors conclude that when organizational structuring, the introduction of new technology, and efforts to innovate and create added value for citizens and businesses operate in tandem, the pervasive complexity associated with delivering government digital transformation projects becomes increasingly difficult to manage.

Keywords:
digital transformation projects; government; project complexity; digital technology; case study.

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1. Introduction

Project complexity has received much attention from practitioners and academics alike during recent decades [1],[2], and significant progress has been made in understanding the different aspects of complexity in projects [3]. Although extant studies provide useful insights into project complexity in a number of industries such as engineering and information technology (IT)/information systems (IS) [4],[5], we still know very little about complexity factors in government digital transformation projects, and what may cause complexity in these projects. Drawing upon the emerging body of literature on project complexity and an in-depth case study approach, we attempt to explore the nature of complexity in a government digital transformation project in Norway.

Digital transformation projects typically involve aspects of information technology, innovation, and organizational change, and therefore require the integration of multiple perspectives [6],[7],[8]. In a government context, the projects require particular treatment due to the extensive size and scope of most of them in terms of time, context, and users [9]. Furthermore, digital transformation project are often referred to as complex, involving a multitude of stakeholders, novelty, bureaucratic organization structures, and political constraints [9],[10]. Despite strong ambitions regarding the potential of government digital transformation, researchers report high project failure rates, cost and time overruns, and unmet functional specifications [9],[11],[12]. Lack of understanding of the complexity of digital transformation and the relationships between technologies, information use, organizational contexts, and institutional arrangements are reported as factors that explain the failures in transforming government organizations [13].

To enable digital transformation, the capabilities of digital technologies should be coupled with factors such as culture, strategy, and human capital [14]. Kohnke [15] found that organizations were investing in digitalization without trying to push the necessary changes, because they underestimated the organizational implications and the human dynamics of the digitalization process, which includes the need to align people, processes, organizational structures, and culture. This indicates a lack of awareness of the interconnections between the important features of digital transformation, and the necessity to consider them in alignment rather than individually. With regard to the use of different digital technologies and various forms of value creation, structural changes are often needed to provide an adequate basis for new operations [11],[16],. This indicates that there is an alliance between the dimensions of technology, innovation, and management.

The purpose of this paper is to provide a better understanding of complexity in government digital transformation projects. In order to investigate the complexities in such projects, our research was based on the following postulate:

> *Complexity in government digital transformation projects is rooted in the interplay between the factors of organizational structuring, technologies, and efforts to innovate. With these factors operating in tandem, the pervasive complexity associated with delivering digital transformation projects becomes increasingly difficult to manage.*

The research was performed in Norway in 2019/2020. The method was a qualitative, in-depth case study, based primarily on interviews, and supplemented with observations and document studies. The selected case is an ongoing digital transformation project in Norway that includes collaboration between several government agencies and sectors with the aim to produce seamless, digital services for citizens and businesses. We used a thematic analysis approach, and qualitative data analysis software was applied to organize the data and explore potential relationships between the themes that emerged.

This paper offers one approach to understanding the complexity of governmental digital transformation projects. We explore the relationships and the interconnections between core dimensions, including the organization, technologies, and innovation. By investigating the root causes of the complexity of digital transformation projects, we aim to raise awareness of the difficulties of embracing and managing such complexities.

In the next section, we introduce the theoretical background with reference to related work on digital transformation projects and project complexity. In Section 3, we outline a conceptual framework (a Venn diagram) for investigating the interplay between variables related to organization, technologies, and innovation. Thereafter, in Section 4, we describe the case and our research design and methods, and we include an explanation of how the case study was conducted and

the data analysis was undertaken. The main findings are presented and discussed in Section 5, including in relation to relevant literature. The paper is concluded with an explanation of the main research results, a description of the limitations of our research, and proposed themes for further research (Section 6).

2. Related work

2.1 The core dimensions of digital transformation projects

To investigate complexity in government digital transformation projects, we choose to focus on factors related to the dimensions of organizational structuring, technologies, and innovation, as several authors refer to them as being the core of digital transformation projects [6],[7],[11],[17],[18]. The three mentioned dimensions have been reported as important elements that pose challenges for the management of digital transformation projects [19].

Organizational structuring in digital transformation projects include factors such as project planning and management, coordination of the project team and the tasks, stakeholder management, governance, and organizational power and politics [10],[18]. All of the factors influence the project execution and management process. In other words, the organizational dimension concerns the "how" and the "who" of the project in terms of *how* the project is organized and executed, and *who* is involved.

In addition to co-creation of value and cross-jurisdictional networks, typical features of government digital projects are the increased use of inter-organizational, cross-sector collaboration [20],[21],[22]. Inter-organizational collaborations are motivated partly by new opportunities afforded by digital technologies [23] and partly by organizational redesign sparked by processes related to new public management (NPM) and public value management (PVM) [24],[25]. The resulting organizational configurations imply that digital transformation projects have to deal with increasing numbers of stakeholders and increased complexity [26]. This situation presents specific challenges for a project's delivery of consistent public value with respect to efficiency, transparency, and accountability [27].

Technology is a fundamental element of any digital transformation project, and therefore it is important to understand the current state of technology being used in a project [10],[13],[17],[18]. In digital transformation projects, technologies are typically defined as combinations of *social*, *mobile*, *analytics*, *cloud*, and the *Internet of Things* (IoT), often referred to as the SMACIT technologies [28],[29]. The use of SMACIT technologies distinguishes digital transformation from previous IT-enabled transformations. The adoption of the technologies is a new venture for many governments, as the scale and scope of the changes associated with their use are unclear [30]. Additionally, *platforms* are cited as an important category of technology used in government digital transformation efforts [18].

Innovation—or *digital innovation*—is regarded as constituting one of the core elements of digital transformation [6],[31]. The use of digital technology during the process of innovating is referred to as digital innovation [32]. Digital innovation concerns, among other things, radical changes in the nature and structure of new products and services, resulting in novel value creation. Since, in most cases, digital transformation is realized through projects, the characteristics of digital innovations will impact management of digital transformation projects [6]. Authors have reported that the intersection between digital transformation and innovation is multifaceted and multidimensional, and thus challenging to manage [18],[31].

2.2 Project complexity

The rapid technological advancements and rapidly changing organizational environments have contributed to projects becoming increasingly complex [33]. Baccarini states that project complexity consists of "many varied interrelated parts and can be operationalized in terms of differentiation and interdependency" [34]. This definition has been further developed by the inclusion of organizational complexity and technological complexity [35]. Subsequently, Geraldi and Adlbrecht [36] expanded the complexity concept by including the softer aspects that can be found at the intersection between people and organization, such as politics, ambiguity and empathy. A further element that is considered a dimension of project complexity is *uncertainty*, which concerns uncertainties in goals and methods [35].

According to Browing [37], a complex project comprises multiple and multidimensional activities that are interrelated in various ways, thus enabling the achievement of a shared goal or objective. Following the work by Browning, Oehmen et al. [38] identified four characteristics of complexity in projects: (1) it contains multiple components; (2) it processes a number of connections between the components; (3) the interactions between components are dynamic, and (4) the behavior of the project resulting from the interplay among the components cannot be explained as the simple sum of the components. The four characteristics are interconnected in dynamic and extensive relationships that impact the behavior of the project. Therefore, project complexity models should take on a holistic approach and be able to capture the important types of variables, and assist in describing and understand their relationships [33].

The project complexity literature differentiates between *structural* and *dynamic* complexity [4],[35],[39]. Structural complexity refers to the number and types of elements and their relationships in a project, whereas dynamic complexity refers to the "behavior" of the project. *Structural* complexity, which is also known as descriptive complexity, is defined as consisting of several interrelated or interacting elements, of which interdependence is a strong characteristic [34]. It also refers to organizational and technical complexity [35]. The organizational complexity consists of the structure of the project organization, including the project's stakeholders and their relationships, as well as the project processes. According to Marle and Vidal, ca. 70% of project complexity factors are linked to organizational aspects [3]. Technical complexity concerns the technical structures of the main deliverables [38] and "softer" aspects such as knowledge and familiarity with advance technologies [34], as well as technology-based project innovation [36], [40], and expertise and skills needed to handle technical risks and requirements [33]. Organizational and the technical complexity are closely interrelated [38].

Dynamic complexity includes aspects that impact and "drive" the behavior of the project, such as uncertainty, ambiguity, and variability [39],[41]. Thus, dynamic complexity is not a "static" snapshot of a particular point in time, but rather a matter of evolving complexities. Consequently, control of the individual elements is not a guarantee of control over of the whole project or of the overall behavior of the project [42]. A typical feature of dynamic complexity is uncertainty in both goals and methods [35],[41],[43]. Dynamic complexity may also arise from ambiguity or uncertainty related to the tasks or the system [44]. A further aspect of dynamic complexity is its alignment with factors such as interdependence, unpredictability, and adaptiveness [45].

3. Building blocks for understanding complexity in digital transformation projects

3.1 The interrelated dimensions of digital transformation projects

In an attempt to understand complexity in a digital transformation projects, we chose to operationalize and map the three core dimensions (organization, technology, and innovation) of the studied digital transformation project in a Venn diagram (Fig. 1). Through the Venn diagram, we initially suggest that none of the three dimensions is prima facie more significant relative to the others. Further, we suggest that each of the dimension, in isolation, has some challenges that the project has to deal with. However, as these three dimensions operate within a system (a project), there are interconnections and relations between them [14],[46]. Our primary assumption is that additional challenges and the creation of complexities in a digital transformation project is rooted in the dynamic relations that are at play between the dimensions of organization, technologies, and innovation. The interplay between the variables will constitute the known challenges found in each singular dimension. In this paper, we use the case study and the qualitative data generated from the case to explore the relationships between the three dimensions of project complexity (i.e., organization, technologies, and innovation).

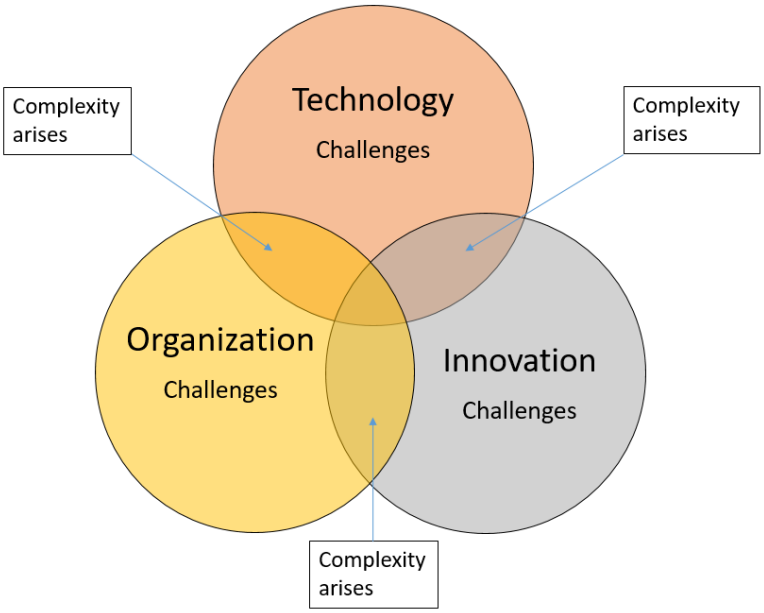

Fig. 1. The dimensions of government digital transformation projects.

4. The case

In 2016, the Norwegian Public Roads Administration (NPRA), together with three different government agencies, decided to collaborate in a digital transformation project with the aim of streamlining the ineffective bureaucratic practice of renewing driver's licenses for professional heavy truck drivers and the drivers aged 80 years or above. In Norway, as in several other European countries, it is mandatory for professional drivers of heavy trucks, buses and minibuses, and for the drivers aged 80 years or older wanting to renew their driver's license, to carry a valid health certificate. The process of obtaining a health certificate, which needs to be renewed regularly, is time-consuming for both professional drivers and drivers aged 80 years or above, as they have to visit their GP ((general practitioner) in person for a health examination, and then take the paper health certificate to the NPRA offices, where driver's licenses are renewed. Behind the "scene", the handling of the driver's license renewal process is ineffective and "tangled", involving coordination of several interrelated tasks between multiple public agencies.

The case project's objective was to streamline and digitalize the analog processes, including the submission of health certificates issued by GPs to the NPRA, saving time and money for the groups of drivers involved, as well as for the GPs who fill out the health certificates and the NPRA, which handles the issuing of driver's licenses. By both developing a digital health certificate and enabling digital transmission of the health certificate from the GPs to the NPRA, the project would render drivers' attendance in person at the NRPA offices superfluous. Another objective of the project is the development of an app for drivers that informs them about the renewal of their license. Drivers could then choose to carry a fully digital driver's license or a physical one. The digitalization of the renewal process would also result in more effective operations at the NPRA and a reduction in the working hours spent on the process and the number of staff involved. In addition, GPS would be more effective, as the completion of health certificates would be less time-consuming.

In order to provide seamless digital services for citizens and businesses, and to streamline the ineffective bureaucratic handling of the process, the NPRA needed to collaborate with the health care sector and the police authority, both of which have important stakes in the management of the driver's license renewal process (see Fig. 2). The health care

sector includes the Directorate of Health and the Directorate for eHealth. The former is responsible for the medical supervision of the health certificate that GPs need to fill out, whereas the latter is the responsible for the digital transformation of the health care sector in Norway. The National Police Directorate, which is the driver's license enforcement body, has traditionally handled administrative tasks in relation to *breaches* of the *Road Traffic Act in cases where drivers' do not have their health certificates updated or in cases of non-compliance with the Act.* The incentives for the National Police Directorate to be a part of the case project were to the opportunity to transfer their administrative tasks and their authorities to the NPRA, reduce the number of public agencies involved, and contribute to streamlining the process of license renewal.

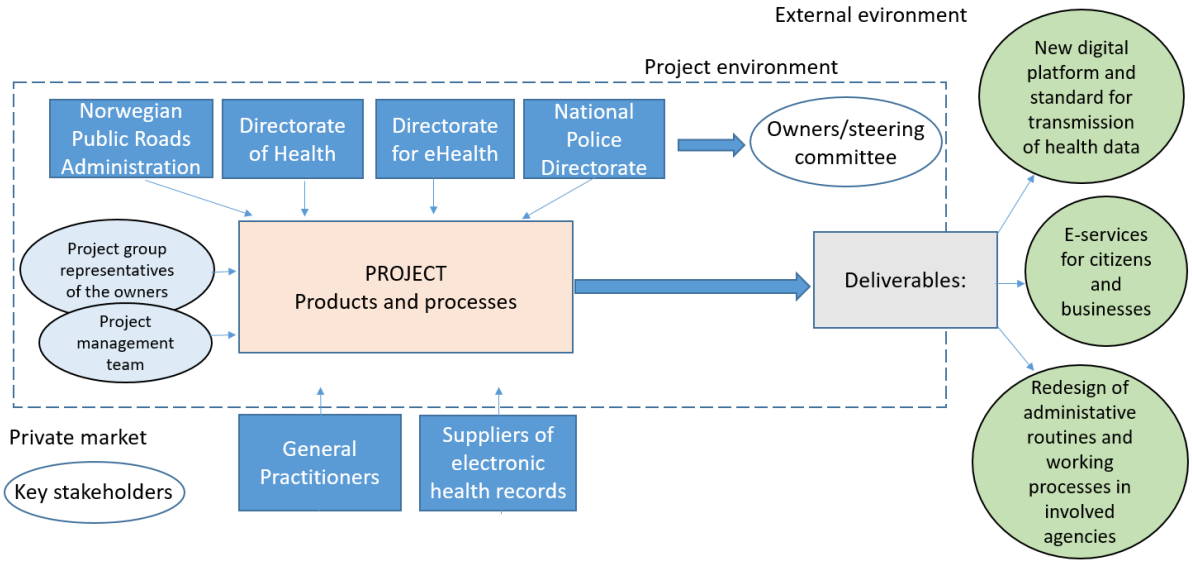

Fig. 2. Overview of the case project and the involved stakeholders.

4.2. The choice of the digital technology

The project's steering group decided to adopt and implement the framework named SMART on FHIR (SMART App Launch Framework), developed in the USA, to facilitate the digital transmission of health certificates from the GPs to the NPRA. The final choice of technology came late in the project life cycle and was a result of recommendations from the Directorate for eHealth, the member agency responsible for the digital development of the health care sector. The chosen digital framework will enable the shift from analogue systems of messages and receipts to real-time sharing of health data among health care institutions and between public agencies. The project was the first to adopt the new technology in the Norwegian market. The project management claims that the chosen digital framework is a "game changer" that may create substantial value for society if adopted by a number of health care organizations. Some of the project's member agencies envisioned this choice of technology as a step forward on the digital transformation journey of the health care sector, while others were wary about the choice, as it might lead to an expansion of project scope. However, all member agencies supported the final decision. A summary of the case-related to aspects of organization, technology, and innovation is presented in Table 1.

Table 1. Overview of the case in relation to organization, technology, and innovation.

Organizational structures	**Technology (digital enabler)**	**Innovation**
Four owners representing three sectors: roads, health, and police	The framework Smart on FHIR (SMART App Launch Framework) facilitates the digital submission of health data.	Transformation from analogue systems for messages and receipts to sharing of real-time health data
Inter-organizational collaboration	Implementing the SMART framework will enable both implementation of, and updates to, electronic health records.	Developing a new application for use by citizens and representatives of businesses when renewing their driver's license
Three major, external stakeholder groups: GPs, suppliers of electronic health records, and citizens/businesses	New technology functionality in the electronic health record (through the use of FHIR) facilitates implementation of a digital health certificate.	Developing electronic health certificates by implementing new standards in the health care sector

5. Research design and method

The aim of our research was to understand complexity in government digital transformation projects. We used a case study as the method for collecting the data. According to Benbasat et al. [47], there are three key reasons why case study research is an appropriate research strategy in fields where information system and (digital) technology are involved. First, the researcher can study information systems and technology in their natural settings. Second, the case study method allows the researcher to answer "how" and "why" questions, in order to understand the nature and complexity of the processes taking place [48]. Third, the case study approach is an appropriate way to research an area in which new insights are sought due lack of previous studies. In this respect, an in-depth case study was considered appropriate for collecting the necessary data and analyzing complexity in digital transformation projects. Furthermore, the single-case study design is commonly used in digital government research [13],[49].

The selection of the case was made on the basis of high expectations about the information content it would provide. Often, a typical or extreme case will reveal more information than other types of cases because it involves several actors and basic mechanisms in the situation studied [50]. For our study, we sought an ongoing digital transformation project that was set up to produce high-end, seamless digital solutions for citizens and businesses. The second criterion was that the case should include collaboration between several public agencies and sectors. Studies have shown that digital transformation projects in the public sector tend to be more concerned with collaborative, inter-organizational strategies and value creation compared with traditional IT projects [51],[52]. A third and final criterion when selecting the case was that it that had been running for some time, thus having the potential to yield information about project experiences.

5.1 Data collection

Data were collected through a combination of semi-structured in-depth interviews, observations, and documentary searches. The findings from the interviews and observations constituted the primary data, while project reports, minutes from meetings, project evaluations, and government reports (e.g., on national digital transformation strategies), constituted the secondary data (Table 2). A total of 10 participants were interviewed (see Table 2).

Each interview was conducted face-to-face and lasted ca. 1 hour. The interviewees were asked to elaborate on the challenges and difficulties experienced in the project, with a focus on aspects of project organization, technologies, and innovation. An interview guide informing about the format and focus of the research study and the interview process was sent to the participants in advance of the interviews. The first author conducted the interviews between November and December 2019. The interviews were recorded and then transcribed verbatim.

The data were triangulated by applying multiple data collection techniques, including multiple interviews, observations, and a review of documents [53] (Table 2). Observations at meetings, document studies, and reviews of project reports, mandates, and evaluation reports were made to validate and provide context for the interviewees' views, thus enabling empirical triangulation. To increase reliability and enhance transparency, a case study protocol was created and a case study database compiled. The database, which was established using the software NVivo, included case study notes, documents, and the results of our analysis.

Table 2. Overview of the collected data.

Data sources	**Number/time used**	**Number, or time used**	**When**	**Type**
Primary data				
Interviews	10	Semi-structured, in-depth interviews with two project managers, the leader of the steering group, a member of the steering group, and six project group members	November – December 2019	Face-to-face interviews
Observations	7 hours	Observations made in two meetings: (1) of project members participating in project group meeting (4 hours), and (2) of steering group members participating in steering group meeting (3 hours)	September – October 2019	Observer at meetings

Data sources	Number/time used	Number, or time used	When	Type
		Secondary data		
Reports such as project mandate, project description, minutes from meetings, evaluations	10	Background information Evaluations of front-end phase, communication plans, budget and planning reports Risk-evaluation matrix Meeting agendas and decision points Financing and operations	May 2019 – April 2020	Written documents
Government's reports and strategies on digital transformation	6	Government agencies' reports on digital transformation initiatives Evaluations of projects and implemented initiatives Government's national digital strategies	May 2019 – April 2020	Online and written documents

5.2 Data analysis

During our research, we use a grounded theory approach [54], which is a systematic method that can assist in the development of explanatory models grounded in relevant empirical data [54]. Interviews are considered a common form of collecting data in research in which the method is applied [55],[56]. We used a thematic analysis approach [57],[54] to analyze the data. The method enabled us to identify patterns in large data set. Further, it offered a means of identifying relations and links within analytic themes both effectively and accurately. Thereafter, a four-step process was applied [57],[58]:

1. an in-depth analysis of the raw data, including coding and identifying first-order categories of codes;
2. further examination of the first-order categories by identifying links, patterns and relationships among them;
3. formation of aggregated dimensions of project management challenges and project complexities, including insights from published literature;
4. comparison and analysis of the aggregated dimensions, which allowed for identification of relationships and linkages between themes.

NVivo software was used to organize and analyze the data from the interviews. The software was especially suitable for ours research because it enabled us to conduct content analysis of rich qualitative data. The process involves "contextualizing and making connections between themes to build a coherent argument supported by data" [59].

The first step involved reading the interviews (located in NVivo) several times and coding common words, phrases, terms, and labels mentioned by interviewees, and then the first-order categories of codes were identified, reflecting the

views of the interviewees in their own words. In the second step, related texts were located together, based on repeated common phrases or ideas. The repeated ideas were grouped into themes to form coherent categories. As the themes started to emerge, the more hierarchal orders of nodes were built, thus creating broader themes related to project challenges. In NVivo the term "node" refers to any named concept that represents what is defined in the data as meaningful in relation to the research project's objectives. To organize themes, NVivo allows them to have more than one dimension (tree branch). In our case, this enabled us to group the themes to build a more general concept. In NVivo this process is labeled as building tree branches. Sorting concepts into branches assisted us in identifying common properties and making early comparisons. To ensure that concerns about validity were addressed [60], insights from secondary resources such as reports and evaluations were taken into consideration. Fig. 3. shows how the first step of the data analysis was performed in one case.

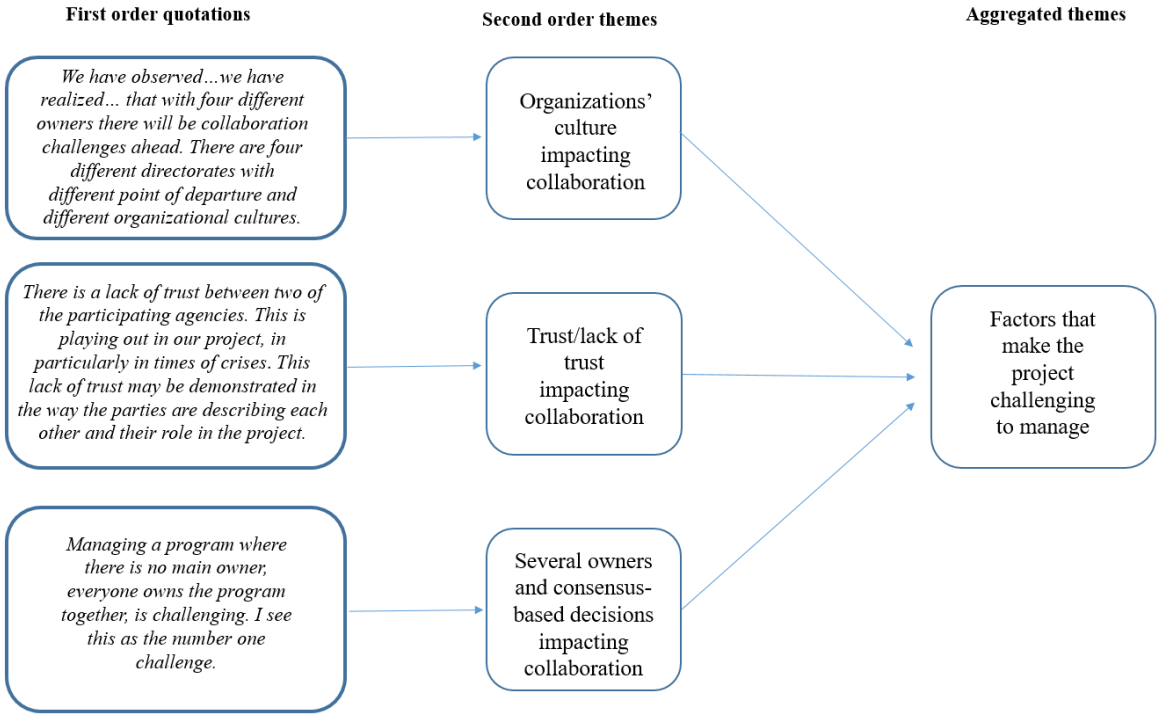

Fig. 3. Examples of first and second steps of coding interview data, the building hierarchy of nodes, and aggregated themes.

The third step in the coding of the interview data generated aggregated dimensions, which represented a higher level of abstraction. In that phase, the second order themes were combined with insights from the literature on project management concerning challenges related to the management of digital transformation projects. An example of the data structure generated from the data analysis in third step is presented in Fig. 4.

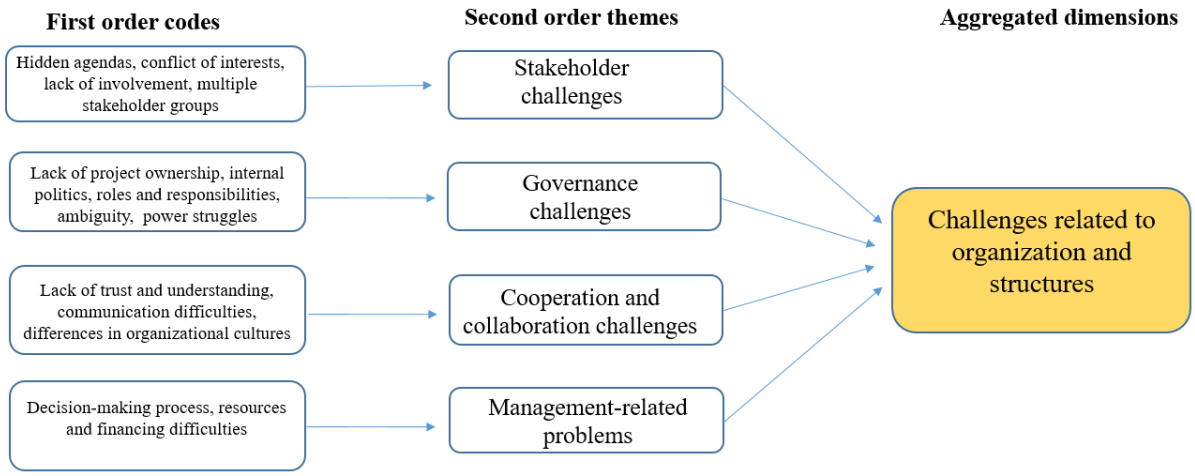

Fig. 4. Examples from the third step in the data analysis process, the creation of data structure related to the organizational dimension.

The fourth and final step included the comparison and analysis of the aggregated dimensions, which allowed for relationships and linkages across them to be identified. The matrix coding query function in NVivo is suitable as a search tool for investigating relationships between themes and concepts [61]. The query examines any possible appearance of themes that are closely associated with each other. The results are presented in tables in which each cell in the matrix displays a chosen piece of information concerning the corresponding pair of items. In our research, the cells contained numbers that represented corresponding coding references (Fig. 5). Consequently, from the results, we were able to examine a number of themes that appeared closely interconnected. Further investigation of these interrelationships might reveal insights into about the emergence of dynamic and extensive relationships between elements that may cause complexity and impact the performance of the case project.

THEMES	Technology/choice of digital enabler	Dependencies in deliveries	Lack of technical competencies	Newness of technology	Progess challenges	Technical deliverables
Collaboration/cooperation challenges	2	10	21	5	3	16
Financing challenges	0	3	3	3	1	4
Governance challenges	3	7	9	4	5	13
Management challenges	5	9	13	6	7	10
Politics: constraints and influence	1	2	2	1	1	1
Stakeholder group challenges	2	5	5	13	2	11
Organizational structural challenges	0	0	2	1	1	0

Fig. 5. Example of a table created by running a matrix query.

6. Results and discussion

In this section we present and discuss the elements of complexities we discerned in the case project. Based on the method described in the preceding section, we were able to distinguish elements of complexities within the dimensions of organization, technology, and innovation. Although the complexities are treated separately to greater or lesser extent in the project complexity literature, the results from our data analysis, which included running matrix queries, indicate that complexity in the studied government digital transformation project incorporated multiple factors and was a result of a dynamic and extensive interplay between complexity elements from all three dimensions.

This section is divided in two main parts. The first part includes Tables 3, 4, and 5, which present the complexity elements prevalent in each of the dimensions. Each complexity element is further described based on an analysis of the interviewees' words, which were aggregated into more overarching themes using the software NVivo (see Section 5.2.). In the second part we explore potential relationships between the identified elements of complexity based on the matrix queries run in NVivo, and the assumption that additional complexities emerged in the interplay between those dimensions. The interplay between the dimensions added up to the known challenges found in each singular dimension.

6.1 Complexities related to the organizational dimension

The group of challenges identified in the organization dimension include governance challenges: lack of project ownership within the participating organizations; cooperation and collaboration challenges, including communication difficulties and lack of trust and understanding between the parties involved; management-related problems; and ineffective decision-making structures. Additionally, resources and financing, stakeholder management, and issues related to politics were identified as elements of complexity within this dimension. An overview of the groups of challenges contributing to complexities in the organization dimension is presented in Table 3.

Table 3. Groups of challenges contributing to complexities in the organizational dimension.

Elements contributing the most to complexities in the organization dimension	**Description**
Collaboration and cooperation challenges	Inter-organizational collaboration, lack of trust, hidden agendas, lack of transparency, differences in the organizations' culture, communication challenges
Stakeholder management	Number and variety of stakeholder groups, multiple owners, lack of involvement of key interest groups (i.e., suppliers), dependencies between stakeholder groups
Governance challenges 3	Lack of steering and anchoring within the participating organizations
Management challenges	Project organization, including frequency of meetings, documentation, ineffective meetings, ineffective decision-making processes, lack of resources and lack of diversity in resources, lack of project maturity among the project members
Financing	Uncertainties about funding, several funding sources and differences in financing mechanisms between the owners; insecure future funding: "who pays for what"
Politics: constraints and impact	Bureaucratic structures, silos, focus on taking care of interests of own sector/organization, political issues, and public administration policies
Structural challenges within the sectors and the organizations	Differences in organizational structures, differences in the sectors' structure, reorganizations within the owners' organization

6.2 Complexities related to the technology dimension

One of the challenges related to the technology dimension was the choice of technology, which was not known in advance of the project's establishment, thus creating a high degree of uncertainty. The project also faced challenges due to lack of technical competencies in the project group, newness of technology, dependencies in deliveries, and changes in requirements. An overview of the groups of challenges contributing to complexities in the technology dimension is presented in Table 4.

Table 4. Groups of challenges contributing to complexities in the technology dimension.

Elements contributing the most to complexities in the technology dimensions	Description
Lack of skills and competencies	Lack of technical and digital competencies, and experiences with technology
Choice of technology/digital enabler	Difficult discussions in the project Technology not known in advance
Technical deliverables	The "hard" deliverables Interoperability challenges
Newness of technology	Challenges of introducing new technology, the platform, to the health care market
Dependencies in deliverables	Multiple dependencies in technical deliveries
Requirements—specifications	Changes in the requirements
Progress challenges	The late choice of technology The change in requirements Dependencies in delivery, impact progress

6.3 Complexities related to the innovation dimension

In the innovation dimension, the main challenges relate to change, uncertainties, and expansion of scope. The chosen technology is a "game changer" in the way that it processes and transmits health data, and thus there is a huge innovation potential associated with it. As the technology is new to the Norwegian health care market, there are uncertainties connected to the acceptance of the digital solutions among key stakeholders, namely the suppliers of electronic health records, and the user groups such as the GPs. Furthermore, there are challenges related to value creation and benefits realization, as the involved agencies are uncertain about where and when the benefits will be realized and the added value created. An overview of the groups of challenges contributing to complexities in the innovation dimension is presented in Table 5.

Table 5. Groups of challenges contributing to complexities in the innovation dimension.

Elements contributing the most to complexities in the innovation dimensions	Description
Uncertainties	Uncertainty related to technology, market adoption, competencies
Change	Introducing change (i.e., in work processes), and new opportunities as a result of the innovative digital services
Expansion of scope	Additional resources and time needed for market research, involvement of political administration, market activities and reach-out efforts
Value creation	Value creation and benefit realization challenges in terms of whom will gain, and where the benefit realization will occur

6.4 Summary of the elements of complexity related to organization, technology, and innovation

In sum, results of our analysis indicate that the case project has experienced complexity related to organization, technology, and innovation. The identified groups of complexity elements resonate with the results and the conclusions of several other studies that identify and categorize complexity factors into organizational, technological, and innovation related groups [33],[39],[62]. The identified groups of complexity elements separately constitute management challenges for the project. Researchers have responded to these types of challenges by presenting a multitude of strategies and management tools for how to embrace, tackle, and manage complexities related to organization, technology, and innovation [5],[33],[63].

The trend in the project complexity literature is for a stronger focus on projects that are unique and should be treated as such, explicitly taking into account the contextual and environmental influences [64],[65]. Accordingly, we assume that the project case we studied has some contextual aspects that makes it unique, for instance the public context in which it operates. Researchers also report that projects that are set up to deliver digital and IS solutions can no longer be regarded as purely technologically focused endeavors, as the complexity embedded in such projects has multiple implications [5]. In line with this thinking, we assume that complexity in the studied government digital transformation project incorporates multiple factors and is a result of dynamic and extensive interplay between complexity elements from all three dimensions.

6.5 Investigating the interplay between the organization, the technology, and the innovation dimensions

Given that with organizational complexity, digital technology, and innovation, the level of uncertainty and complexity in digital transformation projects increases [31],[66], we investigated the intersections in which the dimensions of organization, technology and innovation meet. The results emerging from the following intersections are elaborated as follows:

- Complex situations that arise at the intersection between managing organizational issues and the efforts made for the selection and implementation of new technology;
- Complex situations that arise at the intersection between managing organizational structure and attempts to acquire and introduce innovative digital solutions that create value for users and end users;
- Complex situations that arise at the intersection between efforts to introduce innovate digital solutions, and efforts to select and implement purposeful digital enablers. This intersection defines the space of possibilities.

With regard to the first of the three points listed above, high correlations generated from running a matrix query indicate that the challenges of cooperation and collaboration (organizational complexity) in the project are closely related to a lack of technical competencies within the project group (technical complexity). The members in the project group held different professions, such as GPs, engineers, lawyers, and IT experts. The variety of professions in the project group made the communication among the members demanding, particularly during the process of selecting the digital enabler. The lawyers and GPs, who represented the bureaucratic side of the project group (the National Police Directorate and the Directorate of Health) did not have the same technical competencies or digital skills as the IT experts from the Directorate for eHealth and the NPRA. This made communication and discussions about the technology complicated, as stated by one project member (a lawyer):

> When the “digital side” of the project, i.e., those with the technical expertise, tried to explain the challenges of the digital solution to those of us lacking digital competencies, we talked past each other. The bureaucrats that lack the technical competencies could not make themselves understood, nor could they understand what the IT experts explained, as they were not speaking the “technical language.” The consequences being that those with little technical competencies needed “three rounds of explanations” from the IT experts prior to understanding the technology and the challenges associated with the technical solution.

Gaps between the parties in their digital competencies and experiences with technology impacted the project performance in terms of time overrun, as described by the project manager: “We have had long and difficult discussions about technology, as several members of the project group do not understand the technology, they lack competencies, and how a digital development project is undertaken. This has been demanding, impacted the progress, and somehow exhausted the project and its members.” The results of our analysis indicate that the interplay between the organization dimension and technology dimension is a meeting between bureaucrats and technocrats. The two parties represent different cultures and communicate using different jargon, the technocrats use the ICT jargon of the digital world and the bureaucrats speak the civil service jargon of the bureaucratic universe. They also have different starting points with regards to technical competencies and familiarity with advance technology.

An inter-organizational project that is set up to deliver seamless digital services for citizens typically involves parties that represent the different government agencies that have a stake in the development and implementation of the digital service [51]. Several authors have identified and reported organizational challenges in inter-organizational collaboration projects, such as lack of resources, development of adequate organizational capabilities, and cultural challenges [67],[68],[69]. In a digital transformation project, these types of organizational challenges may interplay with the challenges of selecting and implementing new digital technologies. As observed in our case study, the project had to deal with collaboration challenges such communication difficulties and differences in organizational cultures among the project members, coupled with challenges related to technology, such as the lack of technical competencies. These interrelated elements of complexities may lead to misunderstandings, lack of progress, and time overrun.

A recent study of complexity factors in the ICT industry [65] revealed that "interfaces between different disciplines" is an element of complexity in ICT projects. The authors explain that the challenges faced in the collaboration between parties that represent several sectors can be well understood, as inter-organizational projects can involve close collaboration between sectors that do not have a history of cooperation. In addition, these types of projects have to rely on interfaces in order to achieve a broader public goal. Furthermore, studies of project complexity in IS projects show that technical aspects, such as lack of knowledge and familiarity with advanced and new technologies, and lack of skills and competencies in handling technical risks and quality requirements, will impact the organizational processes and management of projects [34],[70]. Furthermore, studies of complexity in IS projects reiterate that selecting the right competencies is highly critical for coping with technological complexity, and should be considered an important task of the project manager [5]. In government digital transformation projects, the ability to select and devote the right resources to the project might be a more critical problem and one that that occurs in current project practice in the public sector, namely the problem of dealing with constrained resources [68], which also impacts the selection of people and competencies for a project.

The results of our investigation into the relationships between the challenges that arise at *the intersection between managing organizational structure and attempts to acquire and introduce innovative, digital solutions* suggest that the management of the stakeholder relations (a complexity element identified in the organization dimension) is closely connected to the uncertainties of introducing digital innovation to the market (complexity related to innovation). There are uncertainties related to the stakeholders' acceptance of the digital innovation, such as whether GPs will make use of the digital services delivered by the project and accept the changes in the work procedures. According to the project manager, the acceptance of the digital solution introduced by the project is a "make or break" situation for the project: "The technology choice and the importance or challenge of getting the suppliers of the EHR [electronic health record] and the general practitioners onboard, convincing them that this solution will benefit them, on a larger scale, is the major challenge of the project. If the GPs do not use the system then the project will fail." As our findings indicate, the project is highly dependent on the external stakeholders for creating added value for the end users and therefore meeting the stakeholder groups' expectations are key for succeeding. However, as the project has to balance the stakeholders' needs and expectations with the challenges of introducing innovative digital solutions to the market, additional challenges emerge.

The uncertainties associated with the implementation of the new innovative technology are concerns that were highlighted by the project members: "The project has to take on the responsibility of pushing this digital solution into the market, which has expanded the scope of the project. The project had to investigate possible new opportunities by investing in research, [and] documenting the impact and positive effects of the chosen technology." These efforts in supporting the introduction of the new technology may have had negative consequences for the involvement of key stakeholder groups, such as the suppliers, as reported by one interviewee: "The project has lost its window of opportunity, as too much time has been spent on discussions and researching the effects of implementing the new technology. So, if we will launch the new, innovative framework next year, we have lost momentum. Only a handful suppliers have so far confirmed their commitment to implement the applications provided by the framework."

Our results indicate that the challenges of meeting the expectations of key stakeholder groups are closely related to the challenges of bringing innovative digital solutions to the market. The project managers have to balance the expectations and involvement of the stakeholders, and they have to manage the uncertainties related to introducing innovative

services to users. As demonstrated in by the case project, too much focus on one part (i.e., the introduction of new innovative digital solutions) may have negative consequences for the project, such as lack of commitment from the key stakeholders. According to Gil-Garcia et al. [71], balancing the different expectations of the various stakeholder groups is challenging. However, if successful, it increases the likelihood of stakeholder acceptance and the adoption of new services. By contrast, if stakeholders' expectations are not met, the collaboration between the partnering public and private organizations will be less likely to grow, resulting in lack of commitment to the services being delivered by the project. Due to the challenges of bringing innovations to the market, which is demanding and requires strong alignment and commitment between project participants, the need for extensive market research, and a clear execution plan [72], the complexity level will increase. As observed in the case project, the introduction of new innovative technology to the market resulted in expansion of project scope, since unplanned market activities were required, which in turn influenced the project's efforts to meet the expectations of key stakeholders.

Our investigation into *relationships that arise at the intersection between efforts to introduce new digital solutions, and efforts to select and implement purposeful digital enabler* revealed close connections between, on the one hand, the challenges related to the newness of technology (technical complexity) and the challenges related to changes and expansion of project scope, and, on the other hand, the creation of benefit for the users and end users (complexity related to innovation). The selected technology is associated with novelty and uncertainties, as it is new to the Norwegian health care market and will change the way the market transmits health data. The project members expressed concerns regarding the choice of technology, possible expansion of scope, and the achievement of the target benefits for users and end users: "We need to know more about the technology and the concept, as the development of this will expand the scope of the project. We need to know the true potential, where and how the technology can be applied." A recent study of innovation and complexity revealed that innovation is connected to technical complexity [62]. However, the extent to which innovations are invented within a project or adopted from other sources will influence the overall complexity of that project. Cantarelli argues that introducing innovations developed by other sources (projects) requires particular resources, technical skills and experience with technologies [62]. In the studied case, the project has not been involved in the innovation process of the digital framework, SMART on FHIR framework (it has been developed by a company in the USA). In addition, several members of the project lacked technical competencies and experience with advance technology. This might have influenced the project's experience of uncertainty about the technological platform's potential and capabilities, and whether the targeted benefits for the users and end users will be achieved.

7. Conclusions, research limitations, and further research

In this paper we have aimed to provide a better understanding of the elements that cause complexity in a government digital transformation project. The results from our case study support our primary postulate that government digital transformation projects become increasingly difficult to manage when organizational structuring, the introduction of new technology, and efforts to innovate and create added value for citizens and businesses all operate in tandem.

Our analysis of a single exploratory case study, combined with document research and insights gained from literature has revealed the challenges and elements of complexities within the dimensions of organization, technology, and innovation. By running matrix queries in NVivo, we were able to explore the relationships between the identified elements of complexity, assuming that additional complexities emerged in the interplay between where those dimensions. The results suggest that there are extensive and dynamic relationships at play between multiple dimensions of organization, technologies, and innovation.

The results from the data analysis of the case project indicate that the interplay between the organization dimension and technology dimension is a meeting between technocrats and bureaucrats. The two parties represent different cultures and have different starting points concerning technical competencies and familiarity with advanced technology, which complicated the process of selecting the digital enabler. Due to gaps in competencies and lack of a common, "technical" language, the communication between the parties became difficult, which had a negative impact on the progress of the project. With regard to the intersection between innovation and organization, the results suggest that the challenges of

selecting and introducing the digital innovation interacted with the challenges of meeting the expectations of important stakeholder groups. As demonstrated, too much focus on one part (i.e., the introduction of new, innovative digital solutions) had negative consequences for the project in terms of lack of commitment from key stakeholders. The results also suggest that at the intersection between innovation and technology there is a need to balance the targeted benefits with the uncertainties of the technological platform capabilities. Lack of technical competencies and experience with advance technology among the project members might have influenced the project's experience of uncertainty about the technological platform's potential and capabilities, as well as whether the targeted benefits for the users and end users would be achieved.

The results of our attempt to understand complexity in a government digital transformation project suggest that the project cannot deal with just one dimension at the time, but has to address the challenges within the dimensions simultaneously, including in a coordinated manner. We conclude that *complexity in a government digital transformation project may incorporate multiple factors and result from a dynamic extensive interplay between complexity elements from the dimensions of organization, technology, and innovation*.

Our results are primarily based on grounded theory approach, which means that they require extensive theoretical elaboration, testing, and contrasting with other theoretical assumptions. Furthermore, our results do not form a basis for generalizations about the complexities in government digital transformation projects, as the investigated relationships are based on a single case project, in a Norwegian government setting. In addition, it should be taken into consideration that a correlation of themes is not necessarily an indication of an interaction of the corresponding dimensions. However, the results may contribute to pinpointing some factors and their relationships that need to be further investigated in order to understand complexity in a government digital transformation project fully. It follows that more research is needed to investigate and test the identified determinants and other determinants that contribute to complexity in government digital transformation projects.

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