

2024

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Recommended Citation

Polyviou, Ariana; Pouloudi, Nancy; Pramadari, Katerina; and Silva, Leiser O. (2024) "A DNA Helix Analogy for Interdependent Mixed Methods Research: Enabling Cross-Fertilizations and Interim Meta-Inferences," *Journal of the Association for Information Systems*, 25(6), 1585-1627.

DOI: 10.17705/1jais.00902

Available at: <https://aisel.aisnet.org/jais/vol25/iss6/4>

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A DNA Helix Analogy for Interdependent Mixed Methods Research: Enabling Cross-Fertilizations and Interim Meta-Inferences

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Abstract

Mixed methods enable a more integrated and insightful understanding of the phenomena we study, but are complex to plan, execute, and document. This applies to concurrent and fully integrated mixed methods research designs in particular, which remain underrepresented in information systems research. In this paper, we extend the prevailing templates for this type of research and propose a new conceptualization. We argue that different research strands (e.g., qualitative, quantitative, computationally intensive, or other) that unfold at the same time need not be independent. Rather, as they run concurrently, they can interact and inform each other through ongoing cross-fertilization. This offers the opportunity for enhanced validation and deeper research insights. We conceptualize how the interaction between the research strands may unfold and we propose a DNA helix analogy to enable and enhance the conceptualization of such interdependent mixed methods research. We further explain the mechanism through which the different research strands interact in an ongoing cross-fertilization, and how interim meta-inferences may be continuously and incrementally drawn, (re)shaping how each research strand evolves. The research process within this conceptualization is depicted in a flow diagram that can serve as a possible roadmap for this type of research. We also show how this process can be documented, contributing to more transparent accounts of how mixed methods research actually evolves. We refer to our research on cloud adoption as an example and further validate our proposed research design with interviews with junior and experienced researchers engaged in mixed methods research. We conclude with a set of principles to guide interdependent mixed methods research and present their practical implications.

Keywords: Mixed Methods, Concurrent Mixed Methods Research, Interdependent Mixed Methods Research, Cross-Fertilization, Recursive Research, DNA Helix, Interim Meta-Inferences

Suprateek Sarker was the accepting senior editor. This research article was submitted on October 25, 2018 and underwent five revisions.

1 Introduction

Mixed methods research brings together different worldviews, enabling a deeper, more integrated and contextualized understanding of the phenomenon of research interest (Lewis & Grimes, 1999; Mingers, 2001;

Venkatesh et al., 2013). During the last few decades, numerous calls in information systems (IS) research have stressed the need to conduct mixed methods studies (Ågerfalk, 2013; Venkatesh et al., 2013; Venkatesh et al., 2016; Zachariadis et al., 2013). The constantly evolving and increasingly complex

technological ecosystems and the proliferation of digital data accentuate this need, as they provide fertile ground for research that enables and synthesizes multiple worldviews and new methodological approaches.

Despite its promise, mixed methods IS research remains limited, due in part to the challenges associated with the combination of different worldviews and the intricacy of its design and execution. In particular, the use of mixed methods employing multiple strands that run in parallel (concurrent mixed methods research) is rare and very often confined by an expectation that the parallel strands should run independently of each other. Data are collected and analyzed, and conclusions are inferred separately for each research strand before final conclusions (meta-inferences) can be reached. Although research in other social study fields, such as education (e.g., Teddlie & Tashakkori, 2006), suggests that fully integrated mixed methods research designs allow for parallel research strands that are not entirely independent and may entail “crossover analyses” (Teddlie & Tashakkori, 2006, p. 24), in the IS literature, we rarely find such designs; even if they are applied, they are not presented as such.

In this paper, we address this gap, arguing for the importance of *interdependent* mixed methods studies. We build on the fully integrated mixed methods design idea to shed light on how such designs unfold. We argue that concurrent mixed methods research often entails a natural—even unavoidable—*cross-fertilization* between different research strands running in parallel. This happens as interim inferences within each strand are repeatedly used in the other, building on and extending earlier interpretations and conclusions while the research team progressively makes sense of the data collected over the course of the research. Importantly, we argue that *interim meta-inferences* may be developed iteratively and incrementally in such research designs, rather than in a one-off synthesis at the end of a research project, as currently portrayed in the extant literature.

In the following section, we reflect on the paucity of mixed methods research in IS and discuss how existing mixed methods research designs have been taken up, emphasizing the few but diverse concurrent studies. We note an opportunity for further development of this type of studies and propose an interdependent mixed methods research design in Section 3, employing the DNA helix as an analogy for appreciating cross-fertilization and interim meta-inferences in mixed methods research. We propose a possible roadmap, in the form of a flow diagram, to guide such research and

present a table that can be used to document its progress. In Section 4, we exemplify the interdependent research design, with reference to a cloud adoption study employing both a qualitative and a quantitative research strand. In Section 5, we discuss the value of this approach, review our research contribution to the mixed methods literature and present a set of principles and their practical implications for prompting and accommodating cross-fertilizations and for drawing meta-inferences incrementally. Section 6 sums up our contribution.

2 Literature Review

Mixed methods provide researchers with an opportunity to gain richer insights into social phenomena of interest, as different research strands or worldviews are combined and synthesized in a single research inquiry (Greene, 2008; Venkatesh et al., 2013; Venkatesh et al., 2016). Building on earlier work by Tashakkori and Teddlie (2003; Teddlie & Tashakkori, 2009), Venkatesh et al. (2013) present three main strengths of mixed methods research: (1) its ability to address both exploratory and confirmatory questions within the same research inquiry; (2) its power to leverage the relevant strengths of the different methods, assisting researchers in making “better and more accurate inferences—that is, meta-inferences” (p. 25); and (3) its role in better understanding a phenomenon, appraising its boundary conditions and opening up opportunities for future inquiries by embracing divergent and/or complementary findings and views. Venkatesh et al. further exemplify how these strengths bring value to the IS field with references to representative published work.

Mixed methods research can serve several purposes: complementarity, completeness, development, expansion, corroboration/confirmation or triangulation, compensation, and diversity (see Venkatesh et al., 2013, for detailed definitions and examples). Researchers can follow different design paths depending on research questions and context, research purpose, epistemological perspective, theory, mixing strategy, the priority of each component (research strands may be equivalent, or one may be dominant), different data collection and analysis strategies, inference quality, and so on (Nastasi et al., 2010; Newman et al., 2003; Tashakkori & Creswell, 2007; Creswell et al., 2003; Venkatesh et al., 2016). “Mixed methods” research typically encompasses different worldviews (e.g., qualitative and quantitative), even though the term has been occasionally been treated as synonymous with “multimethod research” (the latter may refer to different methods employed within a single worldview, e.g., qualitative.¹ This variety in terminology,

¹ We acknowledge that there is a debate in the literature as to whether “mixed methods” and “multimethods” may be used interchangeably or not, especially when the term “mixed

methods” is used with a narrower scope to cover the combination of qualitative and quantitative studies alone (Anguera et al., 2018). The conceptual difference is

conceptualization, and dimensions adds to the richness and value of this research approach but also to the confusion about its application and its complexity. Therefore, certain classification schemes and typologies have been proposed to help address this complexity. In this paper we focus on time orientation and mixing strategies, as these are integral to any mixed methods research design, and we argue that the related existing typologies can be developed further.

2.1 Key Dimensions in Mixed Methods Research Designs: Time Orientation and Mixing Strategies

Research temporality or time orientation is a primary criterion for the classification of mixed methods (Creswell et al., 2003; Tashakkori & Teddlie, 2003; Venkatesh et al., 2016). We focus on temporality because it is used to shape the design of the research early in the research project, serves as a roadmap for its execution, and is reflected in its presentation. According to this criterion, mixed methods research can be classified as sequential or concurrent. In *sequential* mixed methods research, there is a temporal sequence between the studies, which are connected in such a way that the latter builds on the former. *Concurrent* mixed methods entail studies conducted in parallel and independently of each other.

In both sequential and concurrent mixed methods, conclusions that synthesize and encapsulate the results of the different strands are called *meta-inferences*. They can take the form of “theoretical statements, narratives or a story inferred from an integration of findings from quantitative and qualitative strands of mixed-methods research” (Venkatesh et al., 2013, p. 38). Meta-inferences are at the heart of the value of mixed methods research because they are instrumental in allowing a mixed methods study to go beyond the conclusions a single research strand can offer, aiding the development of a substantive theory of the phenomenon of interest (Venkatesh et al., 2013). They also enable mixed methods to embrace diversity, as they reduce the tensions that exist between different paradigms (Venkatesh et al., 2016) and can also be used as a means for validating the results of different research strands (Creswell & Clark, 2007). According to the extant literature, meta-inferences are drawn *after* the two research strands have been completed and the research results from each strand have been processed separately (Teddlie and Tashakkori, 2006; Venkatesh et al., 2013;

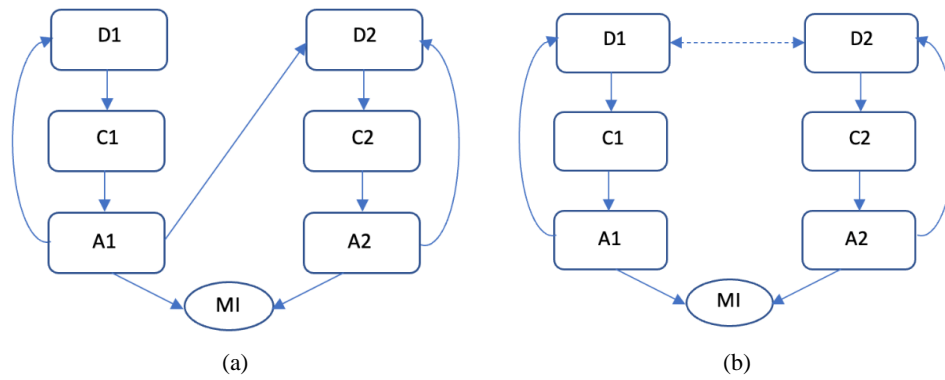
Venkatesh et al., 2016). In Figure 1 we depict these two types of mixed methods showing when the main research stages occur in each strand and when the meta-inferences are derived.

In addition to time orientation, the *mixing strategies* are also crucial in defining a mixed methods research design. They pertain to “the decisions regarding what types of data one integrates and how one integrates those data when designing a mixed-methods study” (Venkatesh et al., 2016, p. 444). Such integration applies to concurrent designs, where integration across strands unfolding at the same time is possible. Tashakkori and Teddlie (2003) define fully integrated mixed methods research as “a multi-strand concurrent design in which mixing of QUAL and QUAN approaches occurs in an interactive (i.e., dynamic, reciprocal, interdependent, iterative) manner at all stages of the study. At each stage, one approach (e.g., QUAL) affects the formulation of the other (e.g., QUAN)” (p. 708—see Figure 2). The mixing strategy can be partial when the mixing occurs at specific stages of the research (e.g., at the data collection stage). The authors provide examples from the literature on different mixing strategies but do not provide generic guidance on how such interaction can be designed or what impact it may have on the course of the research. Subsequent research discussing mixed methods in IS also acknowledges different mixing strategies; however, it focuses on how they are defined rather than how they may be implemented.

A further important limitation is that the description of a fully integrated mixing strategy, based on interaction and iteration across research strands, is misaligned with the definition of concurrent mixed methods research designs, which are presented in the literature as combining *independent* research strands. For example, the “dynamic, reciprocal, interdependent, iterative” manner cited above contrasts with the same authors’ point that “Concurrent Mixed Designs are difficult for novice researchers or researchers working alone to conduct [because, inter alia,] it requires considerable expertise to examine *simultaneously and separately* the same phenomenon using two different approaches” (Teddlie & Tashakkori, 2006, p. 21, our emphasis). This discrepancy has not been addressed in the literature, although it is crucial for understanding and employing concurrent mixed methods research. In the following section, we explore the status of mixed methods in IS research and review recent concurrent studies, reflecting on the limitations presented here.

discussed in Teddlie and Tashakkori (2009) as well as Venkatesh et al. (2013). We consider this debate beyond the scope of our paper, and, in line with Greene (2008), we adopt a broad understanding of mixed methods as enabling “multiple ways of seeing and hearing, multiple ways of making sense of the social world, and multiple standpoints on what is important and to be valued and cherished” (p. 20).

² While this definition has been developed with reference to qualitative (QUAL) and quantitative (QUANT) research strands, its schematic representation would apply equally to other types of research approaches that do not neatly “fit” the qualitative/quantitative dichotomy (e.g., computational analysis, qualitative comparative analysis, or other).



Main research stages: Design (D); Collection of data (C); Analysis (A)
Final conclusions: Meta-inferences (MI)

Figure 1. Sequential (a) vs. Concurrent (b) Mixed Methods Design (Adapted from Teddlie and Tashakkori, 2006, pp. 21-22)

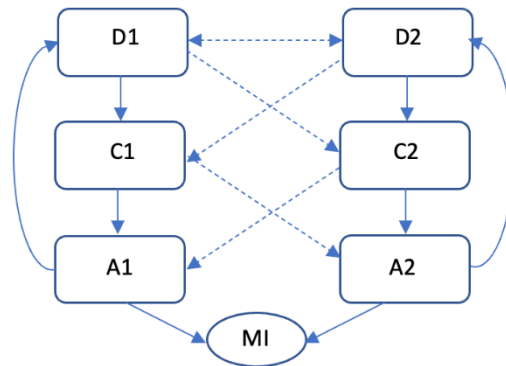


Figure 2. Fully Integrated Mixed Methods Design (Adapted from Teddlie and Tashakkori, 2006, p. 24)

2.2 Mixed Methods in IS Research

Although the value of mixed methods research in IS has been recognized, it remains underrepresented. In the 2001-2007 period, only 3% of the papers published in six of the Senior Scholars’ Basket of Journals (AIS, 2021) surveyed by Venkatesh et al. (2013) “employed a true mixed-methods design” (p. 27). Since then, interest in mixed methods has grown (e.g., the seminal work of Venkatesh et. (2013) has received close to 4000 citations in Google Scholar as of April 2024). In addition to the publication of mixed methods papers in top journals, editorial calls for more diversity in the methods employed in empirical research (e.g., Ågerfalk, 2013; Rai, 2018; Sarker et al., 2018) have also contributed to the legitimacy of this type of research. Even so, we confirmed that mixed methods research papers remain scarce to date, as the percentage of the papers published in ABS 4* IS journals in a recent five-year period (01/2017-01/2022) remains at approximately 3%, with 32 published

empirical mixed methods studies (see Appendix A for our search approach and the list of these studies).

Our review of these papers shows that there are great disparities in the presentation of mixed methods research. Starting with the labeling of the research, some papers do not explicitly brand their work as employing mixed methods. For example, in Anderson et al. (2018), although a few relevant mixed methods references are cited to justify why two empirical studies are used, the authors do not make use of the mixed methods term when referring to their study design. Conversely, Haki and Legner (2021) label their work as mixed methods rather than multimethod research, even though they only employ qualitative methods.

There are also inconsistencies in the manner and level of detail in which researchers present their research design. Because we are interested in studying how IS researchers deal with the challenge of “simultaneous and separate” research strands discussed earlier, we focus on concurrent mixed methods. We posit that the

assumption that the research strands remain independent until the final conclusions (meta-inferences) are drawn by combining the conclusions of each research strand (Figure 1b) runs counter to the nature of research as we understand it; it is iterative, dynamic, and occasionally messy. In particular, given the potential for partially or fully integrated designs (Figure 2), concurrent studies present an opportunity to revisit how meta-inferences are drawn. While in the case of sequential papers it is straightforward that meta-inferences are created, as one strand builds on the conclusions of the prior strand completed, concurrent studies may be more complex and present particular opportunities and challenges in their research design. We therefore turn to the critical review of current IS research practice within such designs.

Only nine of the 32 mixed methods papers we reviewed are concurrent, while studies with fully integrated mixing strategies are absent. It is interesting to note that authors do not always clearly describe the temporality of their work as concurrent. For example, two of the studies describe their approach as mixed methods but not explicitly as concurrent (Jenkin et al., 2019; Jiyong et al., 2021). Other papers provide more details, for example to comment on which one of the research strands was presented as “primary” or “dominant” (e.g., the qualitative in Slavova & Karanasios, 2018). Table 1 summarizes the nine papers, focusing on the types of research strands and methods used, the mixing strategy, and the way in which the meta-inferences are drawn.

Our review leads to numerous observations. First, while not all papers explain the main purpose of choosing a mixed methods approach (see Appendix A), the majority refer to complementarity (Jenkin et al., 2019; Jussupow et al., 2021; Sahaym et al., 2022) or triangulation (Jiyong et al., 2021; Seymour et al., 2021; Slavova & Karanasios, 2018; Vaast et al., 2017). It is also possible to find papers where each research strand serves a different purpose. For example, Jenkin et al. (2019) explain that quantitative analyses served them in data exploration whereas qualitative analyses contributed to a richer understanding.

The papers present great diversity in data collection strategies, ranging from surveys, interviews, focus groups, experiments and panel data to social media data and digital trace data. The latter, more recently employed data collection methods, afford the integration of qualitative and quantitative elements in the same dataset e.g., social media data in the form of Twitter microblogs (Vaast et al., 2017) or data collected through one experiment (Jussupow et al., 2021). Thus, these methods challenge the traditional definition of mixed methods as entailing a qualitative and a quantitative worldview and allow for a broader scope for mixed methods research that also

encompasses computationally intensive and other approaches.

A significant finding of our review is that in most papers, the authors do not clearly define their mixing strategy. In cases where some interaction between the different research strands exists, this is implied rather than explicitly stated. Sahaym et al. (2022) provide an exception, explicitly acknowledging that the dataset of one research strand was employed to support the analysis in the other. Thus, although fully integrated mixed methods are recognized as a possible mixing strategy design in the IS field (Venkatesh et al., 2016), we found no evidence of it employed explicitly in the papers we reviewed.

Equally important is the finding that the way in which meta-inferences are developed is rather unclear. In most cases it appears that they are generated at the end, after the data in the two strands have been separately analyzed, leading to separate conclusions. This indicates that either the authors were not aware of any interaction between the different research strands or they have refrained from documenting it in their paper, for simplicity or other reasons (e.g., compliance with the prevailing template as depicted in Figure 1b). In some cases, the authors’ approach to meta-inferences hints at an interaction during the analysis of findings across the two strands. For example, Jenkin et al. (2019) note that they reflected on the qualitative insights to shed further light to the results of their quantitative strand (p. 657). The same study acknowledges that “data collection and analyses were iterative” (p. 655). In most of the papers, however, authors referred to meta-inferences as arising following the synthesis of the results of the research strands at the end of their study. As prescribed by the literature, authors employed meta-inferences to satisfy the research purpose, answer the overall research question of the study, and derive further conclusions (e.g., Seymour et al., 2021; Haki & Legner, 2021) or validate their findings and develop consensus between the findings arising by the two strands (e.g., Slavova & Karanasios, 2018).

Therefore, our review unveils some inconsistencies and gaps in how concurrent mixed methods are understood and applied. These can be also read as opportunities for diversity and innovation in research design. This interpretation is in line with the argument that research processes are iterative, inductive, and often hermeneutic in nature (Levina, 2021), and a noteworthy common thread across calls for more mixed methods research points out that this type of research should accommodate flexibility and diversity (Ågerfalk, 2013; Creswell & Tashakkori, 2007; Mingers, 2001; Venkatesh et al., 2016). This suggests that there is scope for employing mixed methods research designs that have not been fully explored.

Table 1. Concurrent Mixed Methods Research in Top IS Journals during the 5-Year Period 2017-2022³

No	Paper	Research strands and corresponding methods used	Mixing strategy: interaction between strands	Interim and final meta-inferences
1	Haki & Legner (2021)	Qualitative only (literature review, an expert study, and case studies)	Interdependent/ implied interaction between research strands	Meta-inferences during transcription and afterwards as there is a cross-case analysis
2	Jenkin et al. (2019)	Qualitative (primary study; interviews) Quantitative (to analyze the findings)	Not specified; implies interaction between research strands Three intensive waves; iterative data collection and analyses	Not specified; interim meta-inferences are implied
3	Jiyong et al. (2021)	Qualitative inferencing Quantitative (macrolevel quasi-experiment with microlevel spatiotemporal analyses)	Unclear	Limited mixing at the end
4	Jussupow et al. (2021)	Experimental data (one experiment study that included interviews, survey, think-aloud data) Quantitative (primary)	Unclear	Unclear
5	Li et al. (2020)	Quantitative (survey) Qualitative (teleconsultation video archives)	Unclear	Meta-inferences are generated after the two strands' data are analyzed and conclusions reached separately
6	Sahaym et al. (2022)	Analytical models (primary; game theoretic approach) Qualitative (interpretive case study)	Concurrent triangulation approach (Venkatesh et al. 2013) enabled by the hermeneutic circle	Interim meta-inferences every time there is a breakdown
7	Seymour et al. (2021)	Qualitative (observations, interviews) Quantitative (survey to answer the research questions)	Unclear	Meta-inferences are generated after the two strands' data are analyzed and conclusions reached separately
8	Slavova & Karanasios (2018)	Qualitative (in-depth interviews, focus groups, observations) Quantitative (secondary quantitative data)	The analysis is undertaken in three stages, which integrated qualitative and quantitative data; implied interaction between research strands	Not explicitly stated; interim meta-inferences are implied
9	Vaast et al. (2017)	Quantitative-computational (primary, cluster analysis on social media data) Qualitative (to understand the roles of clusters)	Unclear	Meta-inferences are generated after the two strands' data are analyzed and conclusions reached separately

In this paper we focus specifically on the potential interaction among research strands in concurrent mixed methods studies. We argue that the lack of such interaction or the lack of evidence for such interaction undermines our ability to fully exploit the value of mixed methods research in improving the understanding of the interrelations between the components of the phenomenon or even to open new research avenues (Venkatesh et al., 2013). We wish to

challenge the presumption of independence of the research strands, build on the fully integrated mixed methods mixing strategy by Teddlie and Tashakkori (2006) and explore how IS research can take advantage of an interdependent design to draw, incrementally, stronger meta-inferences in the context of concurrent mixed methods. Prompted by our research, where we employed qualitative and quantitative methods to collect and analyze data on cloud computing adoption,

³ A more detailed description of these papers, with indicative extracts of their methodology presentation, is provided in Appendix A.

we witnessed the value of *interdependent* concurrent research, with intensive interaction across the two strands, in terms of mutual insights gained from one research strand to the other throughout our research project, as explained in Section 4. Such a research experience runs counter to the prescription of concurrent research as one where the two strands run independently and leads to deeper insights within each strand and in the combined research results and better validation of research findings across the two strands. While it exploits the notion of the mixing strategy of a fully integrated mixed methods design, it also goes beyond it, in that it suggests that meta-inferences may be drawn not only at the end of the process but also incrementally throughout the process (*interim meta-inferences*). This novel approach is presented in detail in the next section.

3 The Interdependent Mixed Methods Research Design: The DNA Helix Analogy

Our literature review suggests that the prevailing concurrent mixed methods research design can be extended by defining an *interdependent* design to address two limitations of earlier concurrent designs. First, this interdependent design would allow for the interaction of different research strands that run in parallel, building on the ideas of a fully integrated mixed methods mixing strategy, as presented in Teddlie and Tashakkori (2006). We call this ongoing interaction that can take place between the two strands *cross-fertilization*. Second, in contrast to earlier research, this design invites and accommodates the expression of interim results and insights from each research strand, using them to inform the research process and findings of the other strand in a dynamic, iterative way. The proposed design enables the

synthesis of the results of cross-fertilization into interim conclusions throughout the research. We call these conclusions *interim meta-inferences*. Thus, different research strands benefit from the interim results and insights of one another and their integration, eventually leading to final meta-inferences and the conclusion of a research project.

Figure 3 below presents at a high level how we envisage the different research strands and the process of cross-fertilization and interim meta-inferences. In general, any research strand, whether qualitative, quantitative, or other, passes through the stages of research design, data collection, and analysis. Each stage may have higher or lower importance and different duration, depending on the type of research (this is not depicted in the figure for reasons of simplicity); however, we anticipate feedback loops at different stages, as shown in Figure 3a.⁴ In concurrent mixed methods research, the two research strands run in parallel (as in Figure 3b). In our proposal for a concurrent *interdependent* mixed methods research (henceforth *interdependent* research), two research strands also influence each other through ongoing cross-fertilizations (CF) that lead to interim meta-inferences (IMI), as shown in Figure 3c. Cross-fertilizations may occur across corresponding or different stages of the different research strands. By acknowledging cross-fertilizations and interim meta-inferences in such research design, we can demonstrate *how* the iterations and mixing across the two strands can occur in a conscious way. As cross-fertilizations between the two strands lead to interim meta-inferences, they allow for an incremental synthesis of insights from the research findings and their interpretation as the research unfolds. We posit that this leads to greater research value, as richer final meta-inferences can be drawn.

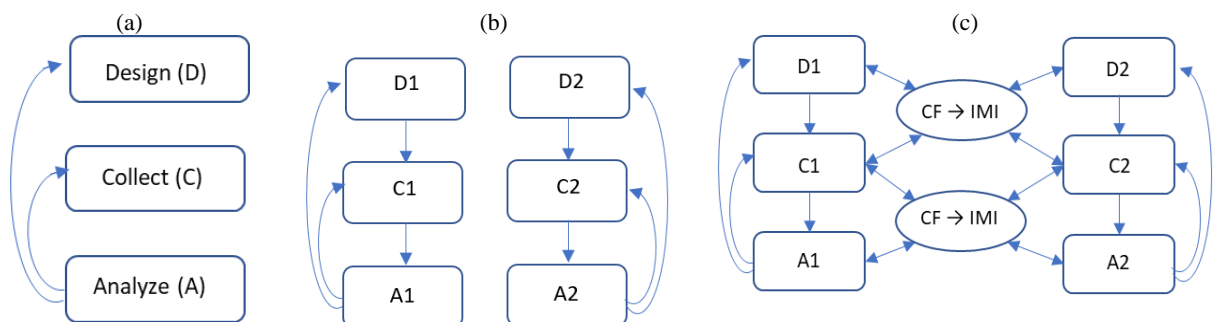
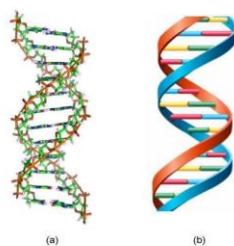


Figure 3. Visualization of Alternative Research Designs

⁴ Feedback loops may occur from any research stage to any of the previous stages. This expands the way in which such feedback loops are presented in earlier research: for example,

Teddlie and Tashakkori (2006) only allow for feedback from the inferential to the experiential (methodological) stage.



Source: Figure 4a: <https://en.wikipedia.org/wiki/DNA>;

Figure 4b: <https://dumielauxepices.net/sites/default/files/dna-structure-clipart-dna-border-504881-7794849.jpg>

Figure 4. The DNA Helix: Its Structure (a) and in Abstract Form (b)

To depict the cross-fertilization process and provide a mental model of how the interdependent research unfolds, we employ the DNA helix⁵ as an analogy (Figure 4). The two strands of the DNA helix⁶ can be used to represent how two different research strands interrelate in the interdependent design. Their *antiparallel* position corresponds to the way in which the two research strands evolve; that is, they do not evolve in a straight, linear fashion but curve and twist while remaining facing each other in a discursive relationship (Figure 4b). The DNA helix representation conveys the impression of a number of consecutive phases, where the helix twists, where both strands may be equally visible, or where one strand may come to the foreground while the other shades off into the background. This visualization readily applies to the research setting where there are multiple cycles; at certain times, both research strands may be equally intensive, while at other times, one strand may take precedence (become “dominant”). The two strands also remain in constant dialogue, as graphically represented by their interconnections.⁷ In Figure 4b, these interconnecting lines may be used to represent cross-fertilization between the two strands. They depict the exchange of insights from one research strand to the other that exploit this “antiparallel” evolution of the two research strands to lead to the development of interim meta-inferences. These may carry implications for research (re)planning and execution as well as for the interpretation of findings from one phase of the research to the next. For example, due to the feedback loops to earlier stages (cf. Figure 3), cross-fertilizations may pick up discrepancies in research findings across the two strands and contribute to their resolution, as interim meta-inferences would indicate the need to revisit earlier

research design decisions and explore how they may have affected the findings within a research strand.

Cross-fertilization and *interim meta-inferences* are further discussed in Sections 3.1 and 3.2, as they are central to our proposal of an *interdependent* research design. A possible flow of the overall research process is described in detail in Section 3.3, while a proposal for documenting cross-fertilizations and interim meta-inferences is presented in Section 3.4.

3.1 Cross-Fertilization

In any research project, researchers critically evaluate the progress of their research and the extent to which it contributes to the phenomenon they study, constantly comparing the extant literature to their research findings (e.g., Eisenhardt, 1989; Klein and Myers, 1999). This is at the heart of any research endeavor, an essential and crucial process that leads to theory building and distinctive contributions. Accordingly, researchers may need to alter (extend or revise) their research design, extend their data collection, or refocus their analysis. This back-and-forth between data and theory, as well as between data collection and data analysis (esp. in the qualitative tradition) and the multiple iterative cycles of data analysis needed to reach interesting conclusions, constitute a natural part of the research process (e.g., Carroll & Swatman, 2000; Levina, 2021). Therefore, it would be odd to assume that in a mixed methods research project, progress in any of the design, data collection, or data analysis phases in one research strand would not influence or provide interesting insights for the others. However, the prevailing assumption that concurrent mixed methods research is *independent*, coupled with the lack of a design template to encourage and

⁵ The double helix “describes the appearance of double-stranded DNA, which is composed of two linear strands that run opposite to each other, or anti-parallel, and twist together” (Nature Education, 2014)—see Figure 4a.

⁶ In biology, these are two strings of nucleotides coil around one another in each chromosome: <https://en.wikipedia.org/>

wiki/Introduction_to_https://en.wikipedia.org/wiki/Introduction_to_genetics

⁷ in biology, representing interactions between pairs of nucleotides, also called base pairs: <https://www.nature.com/sustainable/definition/double-helix-277>

accommodate an interaction between the two strands and with earlier stages of the research, prevents researchers from remaining alert to the possibilities that the research insights of one strand can inform and influence the progress in the other. This potentially limits the opportunity to develop stronger conclusions or inferences. Furthermore, even where such interaction between the two strands does take place, since this process is not foreseen in the extant research templates and exemplars, it remains hidden in the write-up of research results, as it cannot be readily justified or accommodated. As a result, interesting stories on how the research progress unfolded or research conclusions that cannot be supported by an independent research design may remain untold.

We propose the term *cross-fertilization* to refer to and draw attention to the interaction and mutual influence of the parallel research strands. This term suggests a fertile ground for cultivating more sophisticated and better-justified decisions about the research direction of a project.

3.2 Interim Meta-Inferences

While the notion of cross-fertilization refers to the underlying process through which the two research strands interact with and inform each other, the notion of *meta-inferences* describes the outcome of this process. It thus addresses the question of *what* can be learned every time a cross-fertilization occurs. While we remain consistent with the definition of meta-inferences in Venkatesh et al. (2013), we extend it to acknowledge the existence of *interim meta-inferences* that may exist in interdependent research designs. We posit that the possibility of deriving interim meta-inferences through cross-fertilization (zooming into the interactions depicted in Figure 3c; see Figure 5) can lead to the higher validity and quality of final research conclusions (meta-inferences).

Interim meta-inferences enhance the validation of the results of each research strand, as insights from one strand provide additional evidence to support the direction in which the other strand develops. In particular, interim meta-inferences enable researchers

to provide empirical evidence for the validity of their inferences. For example, the initial inferences of a qualitative strand may contribute to the formulation of the research model in a quantitative strand. Similarly, at the analysis stage, insights of an ongoing qualitative analysis may assist in the interpretation of the results of a quantitative survey. In the same vein, the findings of a quantitative study may raise questions that can be explored in further depth in the qualitative strand. In doing so, we have the possibility to empirically validate interim meta-inferences while the research study is still in progress, which further increases the possibility of developing higher-quality meta-inferences and enhances the confirmation or triangulation and complementarity purposes of mixed methods research. In cases where findings from the two (or more) strands do not converge or cannot be readily explained, cross-fertilizations can prompt further investigation to explain the discrepancies or open issues until plausible explanations can be found or opportunities for further research can be articulated.

3.3 The Interdependent Mixed Methods Process Visualization in a Flow Diagram

The DNA helix analogy provides a high-level conceptualization and visualization of the key notions of cross-fertilization and interim meta-inferences. To further operationalize these ideas and illustrate how and when cross-fertilizations may happen, we present a detailed diagram that depicts a possible process flow during an interdependent research design, extending the high-level abstraction presented in Figure 3c. The diagram prompts researchers to address two pertinent questions that can lead to cross-fertilizations across research strands and the identification of interim meta-inferences, respectively:

1. What additional insights can one research strand provide to the other (for research design, data collection, data analysis, and the interpretation of results)?
2. What is the impact of these additional insights on the overall understanding of the phenomenon?

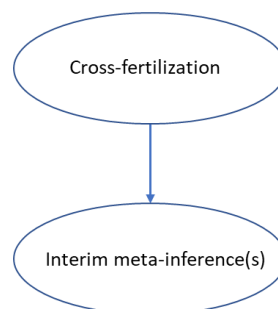


Figure 5. Interim Meta-Inferences through Cross-Fertilization

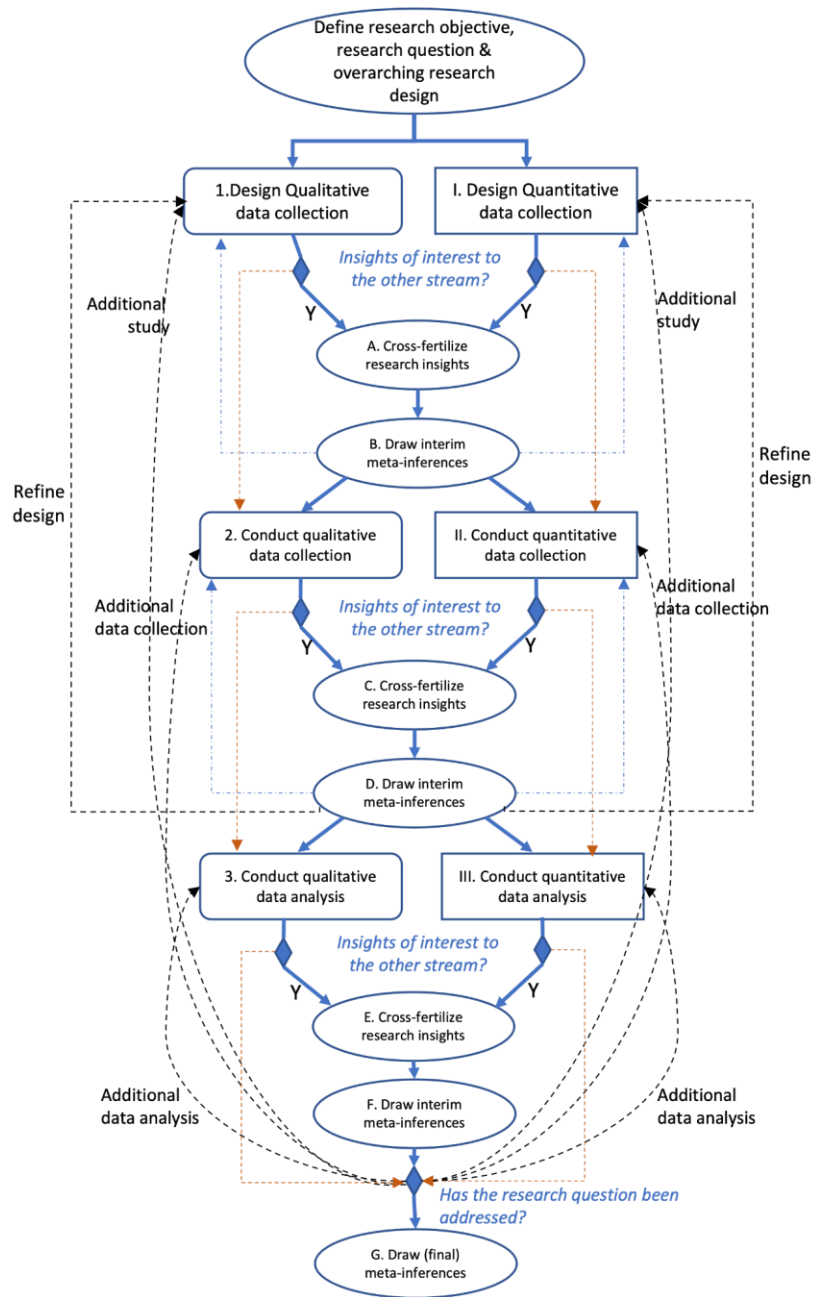


Figure 6. Flow Diagram of a Possible Interdependent Mixed Methods Research Design

The diagram (see Figure 6) uses the basic research stages for each strand described earlier in Figure 3 as building blocks.⁸ These stages are interconnected across the two strands through cross-fertilizations and the resulting meta-inferences (cf. Figure 5). Thus, the diagram illustrates the points where the cross-fertilizations and interim meta-inferences may occur in the life cycle of a research project that encompasses different inquiries that run concurrently and shows the alternative paths researchers may follow as a result of

these cross-fertilizations. The figure is drawn assuming two research strands, one purely qualitative (collecting qualitative data and using qualitative analysis methods) and one purely quantitative (quantitative data and quantitative analysis). This reflects the most common (cf. Section 2) and therefore familiar combination of concurrent mixed methods. We chose this representation to avoid distracting the reader with the added complexity of more sophisticated research designs, focusing instead on

⁸ The assumptions underlying this research design are discussed in the next subsection.

cross-fertilization and interim meta-inferences and explaining how these may come about in interdependent research. Nonetheless, the logic of the diagram applies equally to more complex designs (e.g., computationally intensive research, multimethod experimental designs, and others).

Following the flow diagram, at the start of a research process, the research objective, research question(s), and overarching research design are defined. Based on these [downward arrows], the research team designs the data collection for both strands in parallel [boxes with numbers 1 and I in the diagram respectively]. During this design phase, *ideas*, pilot testing results of a research instrument or decisions about the respondents' profile (for example) in one strand may be of relevance for the design decisions in the other [hence the decision node: insights of interest to the other strand?]. In that case, cross-fertilization [A] occurs, leading to interim meta-inferences [B]. For example, an interim conclusion at this stage may be to extend or narrow down the scope of the research investigation in a certain direction. The interim meta-inferences at this stage [B] may lead the research team to continue working on or revisit the design of either strand [dotted upward arrows from B to Stage 1 and/or I] or to proceed to the data collection phase [downward arrows from B to Stage 2 and/or II]. Cross-fertilization may be triggered by progress in either or both of the two strands. If there are no insights for cross-fertilization, the research process moves on to the next phase [downward arrows from 1 to 2 and from I to II], as in a traditional concurrent research design (cf. Figure 1b).

During data collection [while working in Box 2 and/or II], further cross-fertilization may occur [C], leading to interim meta-inferences [D]. For example, quite early during data collection, field observation in one strand may indicate the need to collect additional quantitative data in another, sample from another population of respondents [leading the research team to follow the upward arrow from D to II or 2 respectively], or reveal additional relevant constructs that need to be measured or concepts that need to be studied, thus revising the research design [upward arrow from D to I or 1, respectively]. Again, if there are no insights for cross-fertilization, the research process moves on to the next phase (downward arrows from 2 to 3 and from II to III).

In the data analysis stage [Boxes 3 and III], interesting results might arise from one strand which could be useful for the data analysis/data interpretation in the other. In this case, cross-fertilization occurs [E], leading to relevant interim meta-inferences [F]. Building on these meta-inferences [F], the research team might continue the data analysis process in further depth [upward arrow from F to 3 and/or III]. We anticipate that this cycle may be the one most frequently exploited by researchers, as they delve deeper into mixing and comparing the findings of different methods. At this

point, the research team may also decide that further data collection is necessary [upward arrow from F to 2 and/or II] or that another study is necessary [upward arrow from F to 1 and/or I]. Finally, once the research team establishes that the research question has been addressed [final decision node], final meta-inferences [G] are drawn—these correspond to the meta-inferences as presented in the literature for concurrent mixed methods research (cf. Figure 1b).

It follows that cross-fertilizations may occur at any stage of the research process, whenever the answer to a decision node: “insights of interest to the other strand?” has a positive answer. This question should be constantly in the mind of the researchers engaged in interdependent research. Therefore, even though the decision node is depicted “below” different research stages in the diagram, it does not necessarily follow the completion of the preceding research stage. Thinking about a cross-fertilization signals a pause in the research process for reflection and discussion among team members, not an end to the research stage that generated it.

3.3.1 Caveats

We note some caveats in the representation of interdependent mixed methods research in Figure 6. First, our focus in this diagram is on how cross-fertilization and meta-inferences develop when different research strands run concurrently. Thus, the diagram portrays two strands, for the sake of simplicity, a purely qualitative and a purely quantitative inquiry. Even so, each of the strands may employ multiple methods (e.g., qualitative data collection may include interviews and observations; quantitative data collection may include an experiment and a survey), or encompass multiple studies (e.g., the quantitative strand may include two different surveys). Second, the diagram portrays the two strands as symmetrical (in line with Figure 3b) for reasons of simplicity and readability. This does not imply that the two strands carry equal weight at all times, that the corresponding phases of the two strands start at the exact same point in time, or that their duration is comparable (e.g., qualitative data collection typically takes longer than quantitative data collection; multiple rounds of quantitative data collection—e.g., two survey studies—may run while qualitative data collection—e.g., observation or interviews—continues; computationally-intensive analyses occur over multiple cycles; and so on). It is also common for qualitative data analysis, in particular, to start while data are still being collected (Phases 2 and 3 may be combined); this is not explicitly indicated in the diagram in the interest of readability. This asymmetry may be more prominent in practice, where a research strand follows a more sophisticated research design that combines, for example, field data and datasets that are jointly analyzed or uses computational analysis of

qualitative data, etc. Finally, the diagram does not include upward arrows to the top to refine or redefine the research question nor does it portray impacts of research evaluation (e.g., during a paper review process) that may guide the research team to return and redraft data analysis, complement data collection, or even revise the research objective and design. These have been omitted for the sake of readability, as they are not directly related to cross-fertilizations and meta-inferences between the research strands, even though they are relevant additional cycles that may influence the progress of a research project.

3.4 Recording Cross-Fertilization and Interim Meta-Inferences

The flow diagram proposed emphasizes the research process and can serve as a possible roadmap to navigate through interdependent research, enabling and prompting the identification and exploitation of cross-fertilizations and interim meta-inferences. However, the diagram is not practical for representing their content.

To address this issue, one option we suggest is the use of the following tabular representation for recording the details of a cross-fertilization and its resulting interim meta-inferences (see Table 2). This format can be used for the documentation of the research progress through some or all interactions between the two strands, e.g., in the researchers’ notes or in a publication.

In this table, the first column presents the current progress in one strand (its status and key findings). The second column explains how this strand can provide insights to the strand whose progress is described in the third column; that is, it explains the content of the cross-fertilization, as well as its direction. The row below describes the interim meta-inferences arising from the cross-fertilization, i.e., the implications and lessons learned from this interaction. This table allows

researchers to “zoom in” on the connecting lines in the DNA helix analogy, focusing on each cross-fertilization and describing what occurs within the “bubbles” of Figure 5.⁹ Cross-fertilization need not be unidirectional; for example, the two strands may at the same time inform each other’s design or analysis.

The next section shows how we have employed the interdependent research design in practice. We also exemplify how this helped our research progress through a series of cross-fertilizations and interim meta-inferences that enriched the quality of the research design and results of both strands. This process enables richer insights and accommodates research stories that an independent design would have left untold.

4 Concurrent Interdependent Mixed Methods Research: A Case from Cloud Computing Adoption Research

The work proposed in this paper emerged from our effort to conduct a concurrent mixed methods research project on cloud computing adoption entailing a qualitative and a quantitative research strand by following the extant research designs. Early in the course of our research, we found the literature restricting, as it could not accommodate the way in which interim findings in the qualitative strand of research influenced the quantitative strand and vice versa. In this section, we briefly describe this research project, which led us to discover the great value in this interaction. We summarize our research aim, strategy, and methods to provide the context of the study, but our emphasis is on showing the interaction between the qualitative and quantitative research strands we followed (cross-fertilizations) and its implications (interim meta-inferences) through examples.

Table 2. Template of a Cross-fertilization in Interdependent Mixed Methods Research

Research Strand 1 (e.g., qualitative)	Cross-fertilization	Research Strand 2 (e.g., quantitative)
Description of progress/findings in this strand	Communication of insights, comparison of results from research strand 1 to research strand 2 or across the two strands	Description of progress/findings in this strand
Interim meta-inferences		
Outcome of cross-fertilization, i.e., interim meta-inferences such as: <ul style="list-style-type: none"> • a (revised) research model • (re)interpretation of findings • a decision to revisit an earlier research phase in one or both strands, etc. 		

⁹ If all cross-fertilizations are documented, the series of tables that would result would mimic the DNA helix, as we could “see” the two strands altering their position from the

first to the last column and back, while the interconnections between them (i.e., the cross-fertilizations in the middle column) persist.

In our research, the objective was to investigate *the cloud adoption decision-making process in organizations and what influences it*. This objective entails an understanding of both the factors affecting cloud adoption decisions and the cloud adoption decision-making process per se. We adopted a critical realism paradigm that could embrace different methods, solving the tensions between interpretivist and positivist epistemological assumptions (Mingers, 2001), as further elaborated in Appendix B. In the qualitative strand, we conducted semi-structured interviews with leading technology decision makers in organizations, focusing mainly on the decision-making process for cloud adoption. The quantitative strand focused on the factors that affect cloud adoption decisions and included two surveys: the first surveyed the perceptions of cloud service users in organizations on the factors leading to cloud adoption, while the second investigated these factors as perceived by the leading technology decision maker in the participating organizations.

The two strands were initially designed to run concurrently and independently, as prescribed in the literature. However, as our research team frequently reviewed progress, we realized that the intermediate findings or design choices of each study had an impact on the other study (cross-fertilization), resulting in revisions in its design and the interpretation of findings (interim meta-inferences). This continuous process of cross-fertilization and the resulting meta-inferences occurred naturally and, initially, unconsciously, as we reviewed the research progress over time. We only became conscious of cross-fertilizations and their significance when we started writing up interim research progress for each strand. This prompted us to revisit our early results and systematically unveil implicit cross-fertilizations that had already taken place between the studies. We also realized that this

process went beyond the prescriptions for concurrent mixed methods research in information systems. This led us to start recording and reflecting on the cross-fertilization between the two research strands that followed intentionally. We also recorded how such cross-fertilization progressively influenced our holistic understanding of cloud adoption (meta-inferences). It soon became clear that cross-fertilizations happened throughout the research process and helped the two research strands coevolve. This did not happen linearly, because ‘twists in the plot’ (i.e., a need to revise parts of our research design or re-interpret earlier findings) were unveiled as we reflected on our research design choices. In the following paragraphs, we describe the overall path of our research using the DNA analogy as well as representative examples of the cross-fertilizations that occurred.

4.1 Overall Research Design

At a high level, our research on cloud adoption decisions involved two interdependent strands, one qualitative and one quantitative, running in an antiparallel fashion: Rather than evolving in a straight, linear fashion, each one followed its own pace, while constantly informing each other. Figure 7 provides an illustration of our overall research design using the DNA helix analogy. The numbers shown on the arrows correspond to the main cross-fertilizations that took place between the two research strands. These are explained in detail in Appendix C. The figure also illustrates how the whole research evolved in three iterations, each iteration building on the findings and interim meta-inferences of the previous one. In the following section, we briefly describe these iterations and then provide a detailed example of two cross-fertilizations, one for each direction (qualitative to quantitative and vice versa).

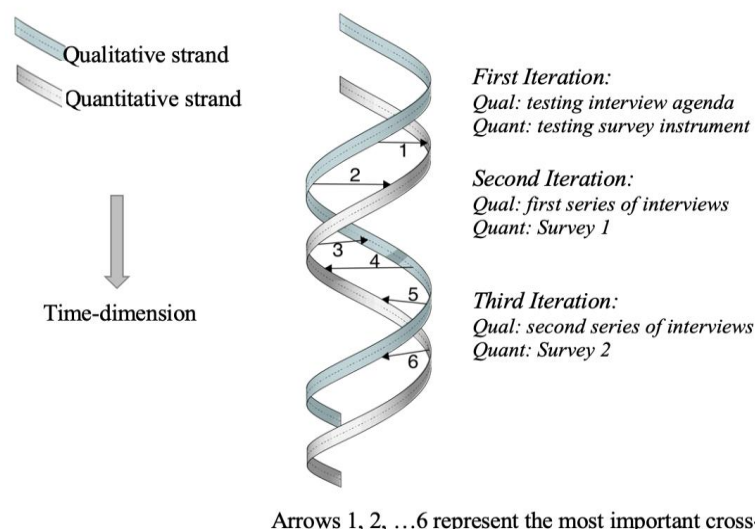


Figure 7. A High-Level Illustration of Our Research Design, Employing the DNA Helix Analogy

First iteration: At the start of our research on cloud adoption we wished to better understand the context of the study. We were a research team of three: a new PhD student and two advisors, one experienced in qualitative research and one in quantitative. We chose to follow a concurrent mixed methods research design which enabled us to take advantage of the mixed expertise within the research team to achieve complementary results and richer insights while making the best use of time with the two strands evolving simultaneously. We decided to conduct a pilot study first, with a small number of participants, to test our approach for the qualitative study (interview guide) as well as the measurement instrument for the quantitative study (questionnaire). This also allowed the PhD student to familiarize herself with the respective methods.

Second iteration: Building on the findings of the first iteration we then moved to the first series of interviews of the qualitative study (12 interviews), which investigated cloud adoption. In these interviews “remote access,” “cost-reduction,” and “security concerns” emerged as key factors influencing cloud adoption in this context. At the same time, the first quantitative study (Survey 1) defined the cloud’s relative advantage and then tested its impact on the decision to adopt the cloud in the context of cloud-enabled payroll systems. The findings of the two studies enhanced the understanding of cloud adoption decisions and provided implications for the third iteration.

Third iteration: Building on the findings of Survey 1, the interview agenda and questions were revised, and we started a new series of interviews (18), aiming to analytically breaking down the cloud adoption decision-making process into its constituent phases. We employed sensemaking theory and, by drawing on interviews with CIOs and CEOs/Directors, we theorized the process of cloud adoption sensemaking. The analysis of the data led to the identification of patterns followed by decision makers when considering cloud adoption. In parallel to this, the quantitative research strand continued with a new survey (Survey 2) aimed at investigating cloud adoption factors within the specific functions of an organization. By employing the theories of diffusion of innovation and organizational capabilities, we formulated a research model that examines the impact of the cloud’s relative advantage and organizational innovativeness on the decision to adopt cloud-based systems to support specific business operations.

During these three iterations, our research team had frequent meetings to reflect on the interim findings of

each of the two research strands and discuss next steps. The same researchers (three of the paper authors) were involved in the design and interpretation of both qualitative and quantitative research strands, each member contributing according to her expertise. Thus, cross-fertilization happened effortlessly as the two strands progressed.

4.2 Examples of Cross-Fertilizations

During the research process there were various cross-fertilizations, leading to respective interim meta-inferences. Some of them were more instrumental and critical in guiding the outcome of the research project overall. In the following paragraphs, we present two such cross-fertilizations from the second iteration of our research: Cross-Fertilization 2 (from the qualitative research strand to the quantitative) and Cross-Fertilization 3 (from the quantitative to the qualitative) in order to provide examples of both directions. We complement the narrative by illustrating the research progress, highlighting the relevant part of the flow diagram (Figure 6), and documenting how interim meta-inferences were derived using Table 2, as prescribed in the previous section. In Appendix C, we provide an overview of the six key cross-fertilizations depicted in Figure 7, demonstrating in detail how the research process unfolded.¹⁰

4.2.1 Cross-Fertilization 2

In this cross-fertilization, the responses from the interviews up to that point (qualitative strand) enhanced the ability of the researchers to interpret the data of Survey 1 (quantitative strand). The interviews indicated that different stakeholders evaluate the cloud based on different priorities and that users are mainly involved in the pilot stage of the cloud service. The interviews also showed that the cloud adoption decision-making process is complex and seems to differ across organizations of different sizes and that remote access is consistently recognized as a source of value for cloud adoption. At this stage, the results of the quantitative strand demonstrated that security concerns are not significant whereas cost-reduction and remote access are. Interim meta-inferences were useful for the interpretation of these results. For example, the insignificance of cost reduction and security concerns (partly contradictory to existing literature) in Survey 1 can be interpreted based on the argument that such factors are more likely to be examined by the technical people involved in the decision-making process and are not primary concerns for the end users of cloud services, who were the

¹⁰ Additional cross-fertilizations occurred throughout the research process, but they are not included in the paper as their effect was not as significant.

respondents in this survey. Similarly, the significance of remote access could be interpreted using insights from the qualitative strand, which indicate that the need for remote access may be one reason for initiating the cloud adoption decision-making process and that the importance of remote access can be justified by the needs of employees to easily connect to the organization even beyond working hours.

This cross-fertilization is depicted in Figure 8, where the results of the qualitative data collection

(interviews) [2] influence the interpretation of results of the quantitative research strand (quantitative data analysis) [III], through cross-fertilization [C] and its resulting interim meta-inferences [D]. Using the proposed table template, and reading Table 3 from left to right, we can see the specific findings from the interviews that provided explanations for the results of the quantitative analysis and the respective interim meta-inferences that opened up the path for further investigation.

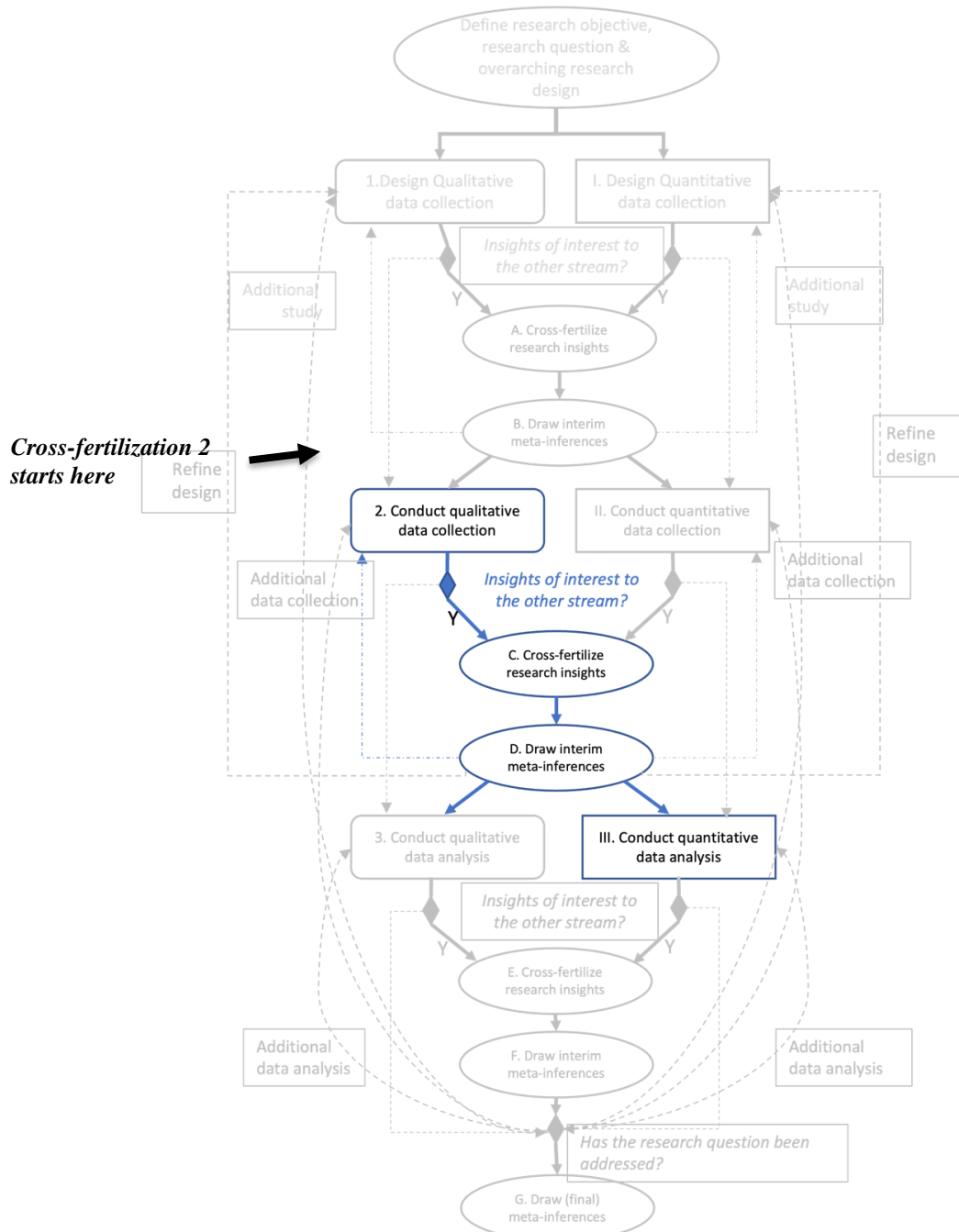


Figure 8. Cross-Fertilization 2

Table 3. Cross-Fertilization 2: From the Qualitative Strand to the Quantitative Strand

Qualitative research strand [2. Conduct qualitative data collection]	Cross-fertilization [C]	Quantitative research strand [III. Conduct quantitative data analysis]
<p>Indicative findings:</p> <ul style="list-style-type: none"> • Different stakeholders evaluate the cloud based on different priorities • Remote access consistently recognized as a source of value • Desire for remote access often triggers initiation of a cloud adoption decision-making process 	<p>The results of the qualitative strand inform the interpretation of the results of the quantitative strand (Who referred to the insignificance of security concerns in the interviews? Who referred to remote access and why? How different were the profiles of respondents in the two studies?)</p>	<p>Survey 1: $R^2 = 0.415$</p> <p>Findings:</p> <ul style="list-style-type: none"> • Security concerns not significant • Cost reduction and Remote access were found significant ($p < 0.01$) <p>Survey 1: Interpretation of results: Enriched by cross-fertilization [C], lead to interim meta-inferences [D]—see below</p>
<p>Interim meta-inferences [D]</p>		
<p>Possible interpretation of Survey 1 results, following cross-fertilization [C]:</p> <ul style="list-style-type: none"> • Security concerns might be more relevant for the technical staff involved in cloud adoption decisions • Remote access: reflects the need of employees to easily connect to the organization’s premises even beyond working hours • Responses may differ if respondents are not actual users of the service 		

4.2.2 Cross-Fertilization 3

The results of Survey 1 also provided useful insights for the qualitative study, especially concerning the coding and analysis of the interview data but also leading the research team to enhance the interview guide, as depicted in Figure 9. In particular, the results of the quantitative strand [III] revealed that responses were different for respondents working in different business areas. It also revealed conflicting results for certain factors, which led us to realize that different factors may have a different impact, depending on the stakeholders involved at different times and in different parts of the cloud adoption decision-making process. As a result of this cross-fertilization [E], we were able to draw interim meta-inferences [F] concerning the importance of different business areas for a company and infer that different factors become relevant at different points across the decision-making process. Such results provided insights on how to further analyze the qualitative data already collected [F → 3]. For example, we found that employees’ need for remote access usually triggers the initiation of the cloud adoption decision-making process, whereas factors such as cost reduction and security concerns become relevant later in the process. These findings initiated a new research iteration, feeding back new insights into the interview guide for the new round of interviews [F → 1].

This cross-fertilization is documented in Table 4. Again, reading the table from left to right, we see how the quantitative strand (it is the *quantitative* research strand that is now listed in the first column) influenced the qualitative strand, as it led us to revisit the interview data and seek evidence to validate the

findings of the quantitative study. Moreover, it revealed new lenses that could potentially explain the different phases and stakeholders involved in the cloud adoption decision-making process.

The two examples illustrate how two specific cross-fertilizations led to interim meta-inferences and shaped the direction of our study. We noted above that at the beginning of our study cross-fertilizations were not happening consciously. As the team recognized this process and its value and became familiar with it, the research progressed and cross-fertilizations increasingly occurred. These cross-fertilizations and the respective interim meta-inferences affected primarily the design of the research and the analysis of results. As the same researcher was conducting both the interviews (qualitative) and the analysis of the survey data (quantitative), findings from the interviews affected, first, the design of the quantitative study and, second, the interpretation of the survey results, even before the first analysis of the qualitative results was completed. This is contrary to what has prevailed in the literature, as discussed in Section 2. This fact alone saved the research team significant time, as it otherwise would have taken a lot longer to reach the same findings and understanding. In a similar way, the quantitative strand affected the qualitative strand (e.g., additional interview questions, insights for data collection) already during the design phase and during the data collection phase (looking at descriptive data and survey responses) but mainly after the analysis of the survey results was completed. Some of the cross-fertilizations initiated loops back to earlier research phases in a manner that has been recognized only within a specific strand in earlier mixed methods literature (e.g., Teddlie & Tashakkori, 2006).

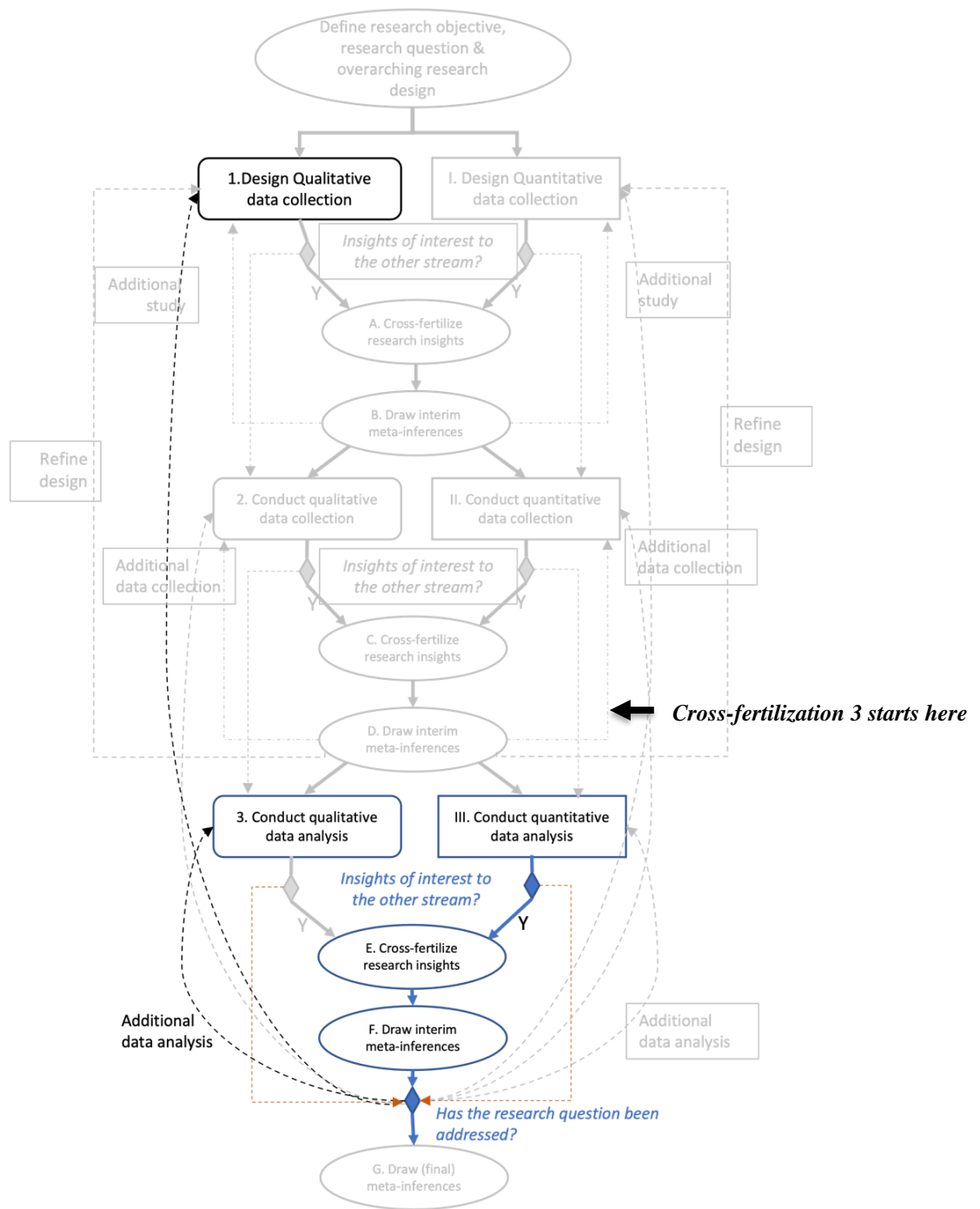


Figure 9. Cross-Fertilization 3

Table 4. Cross-Fertilization 3: From the Quantitative Strand to the Qualitative Strand

Quantitative research strand [III. Conduct quantitative data analysis]	Cross-fertilization [E]	Qualitative research strand [3. Conduct qualitative data analysis]
<p>Analysis of Survey 1 results</p> <ul style="list-style-type: none"> • responses from cloud services’ users may differ across business areas, as survey respondents have a specific context in mind; so, it is important to consider the role of business areas in cloud adoption • conflicting results for certain factors—need to explore further if they may be at play in different phases of the cloud adoption process 	<p>The results of the quantitative strand provide insights and issues for further analysis in the qualitative strand (to review the relevance of business areas; to explore the role of remote access and other factors over the course of the decision-making process)</p>	<ul style="list-style-type: none"> • the decision-making process is complex; it also seems to differ depending on organization size • different stakeholders may be involved in the cloud adoption decision-making process • different stakeholders might participate in each phase (e.g., users’ needs may trigger the consideration of the cloud; CIOs interact with vendors; users participate in piloting services; etc.) <p>Further interpretation of findings and points to clarify emerge following cross-fertilization [E]—see below</p>
<p>Interim meta-inferences [F]</p>		
<p>Further analysis of the interview data, prompted by cross-fertilization [E], shows:</p> <ul style="list-style-type: none"> • Business areas are indeed relevant in the cloud adoption decision-making process • Remote access is found to be significant, and this is explained by the fact that it often triggers the initiation of the process • Cost reduction and security concerns become relevant later in the process, and this may explain why security concerns were not found to be significant (cf. Table 3) 		

In this section we demonstrated how mixed methods interdependent research can be applied, drawing from our experience with a specific research inquiry. While this may appear to be quite complex at first glance, as also depicted in the respective flow diagrams, it is also characterized by some simple principles and habits that, once understood and developed, become a natural process, happening almost automatically. These principles are discussed and analyzed in the next section, following a review of the value of the interdependent design and the research contributions.

5 Discussion

This paper contributes to the growing, yet still underdeveloped literature on mixed methods research. In this section, we reflect on our experience with the use of the interdependent research design and discuss its value (Section 5.1). We then explain how this research: (1) contributes to a reconceptualization of mixed methods research that is not sequential and thus can be interdependent; (2) provides guidance on how to conduct interdependent mixed methods research, drawing attention to the way in which the conscious and deliberate use of cross-fertilizations leads to interim meta-inferences in an iterative process; and (3) addresses the documentation of this process and provides a conceptual toolbox to support these contributions (Section 5.2). Finally, we present five principles that consolidate the lessons learned from this research and related practical guidelines for researchers engaging with mixed methods (Section 5.3).

5.1 The Value of the Interdependent Research Design

As discussed in Section 4, already in the early stages of our research on cloud adoption, we were able to recognize the value of the interaction between the qualitative and the quantitative research strands, which led us to richer insights concerning our research findings and their interpretation. However, we found no guidance in the literature on how to systematically exploit and acknowledge such cross-fertilizations and thus on how to document and validate certain design decisions (e.g., additional hypotheses or interview questions). We addressed this gap, by developing organically over time a research design that prompted us to think systematically and continuously about potential cross-fertilizations and their interim meta-inferences. Such insights would have otherwise been missed. Building on these insights, we were able to gain a deeper and more holistic understanding of the phenomenon in our case cloud adoption.

Although we naturally and unconsciously began to draw insights from one strand to inform our research direction in the other, as discussed in Section 4, we quickly came to realize the significance of this process for an enhanced understanding of cloud adoption as well as for research validation. Indeed, we gained greater confidence in the validity of the research results because we were able to identify discrepancies and gaps in our understanding early in the process before either strand—or any research stage within either strand—was concluded. Using the interim meta-

inferences, we proceeded to revise the research course where necessary, making our results more coherent and streamlined across the two strands. In practice, this research design enabled ongoing triangulation. On the one hand, findings that were confirmed both from a qualitative and quantitative perspective gained higher validity. On the other hand, the unexpected or contradictory findings comprised a significant outcome of the cross-fertilization process because they marked the beginning of a new cycle of inquiry or analysis that lasted until we could resolve or explain them (as reflected in interim meta-inferences), leading us to a deeper understanding of the phenomenon. This explains why our use of mixed methods progressed to serve the purposes of completeness, development, expansion, and confirmation, rather than just complementarity. As we noted in our literature review, complementarity and triangulation are the most frequently stated purposes for concurrent mixed methods research. In this respect, our approach enables interdependent research studies to claim a more ambitious research purpose.

We need to recognize the effort and complexity associated with conducting concurrent mixed methods research, as also noted in the literature (Nastasi et al., 2010; Teddlie & Tashakkori, 2006). Indeed, in our cloud computing research example, following an interdependent approach added a layer of complexity to the research process, as the progress and results of the qualitative and quantitative strands were constantly compared, and their flow was disrupted every time a cross-fertilization occurred. Furthermore, the detailed documentations of cross-fertilizations and interim meta-inferences may be lengthy and cumbersome. However, they can help researchers defend and explain research design choices and changes in research direction. Such documentations thus provide a systematic way to address an important limitation found in earlier mixed methods research work, where partial information may have been provided for the research design and, most notably, the mixing strategy and the way in which meta-inferences were derived. Indeed, our review of concurrent papers in Section 2 concluded that the development of meta-inferences is often unclear, and while some papers hint at an interaction between research strands, this is rarely, if ever, explicitly acknowledged and explained. Our critique is in line with recent calls in our discipline to acknowledge the complexity and iterative nature of IS research. As a case in point, Levina (2021) challenges the rationalized, clean, modulus approach of presenting theory development papers in IS and argues for more transparency in the empirically grounded theorizing, as this could enable readers to fully consider the implications or the appropriateness of the research approach. Our work echoes such arguments within the context of concurrent mixed methods research.

In this respect, our approach addresses the lack of clarity and provides appropriate vocabulary for recognizing and recording the importance of mixing strategy in concurrent designs. It acknowledges that each research strand can have a significant impact on improving both the design and the interpretation of the results of the other, leading to greater cumulative overall value and knowledge assimilation. Importantly, it adds value to mixed methods research by encouraging clarity in the description of the research design and the research process and offers tools for its detailed documentation. The following section reviews the research contributions in detail.

5.2 Research Contributions

This paper contributes to the growing yet still underdeveloped literature employing mixed methods research. Primarily, building on earlier impactful work on mixed methods typologies (cf. Section 2), the proposed interdependent design extends earlier views of concurrent mixed methods research, where qualitative and quantitative research strands typically run in parallel, independently of each other, and only come together once completed to provide a synthesis of the results (meta-inferences). Our design questions the independence of research strands and extends and develops the fully integrated design initially presented by Tashakkori and Teddlie (2003; Teddlie & Tashakkori, 2006), showing the process and mechanisms through which final meta-inferences may be incrementally and iteratively built. Cross-fertilization and interim meta-inferences are two central concepts that we propose. *Cross-fertilization* represents the dialogue between two (or more) research strands that evolve in an antiparallel way (rather than in parallel and independently). The *DNA helix analogy* depicts this conceptualization at a high level of abstraction, providing a simple illustration of the inherent complexity of *interdependent* research. It shows how this antiparallel, interdependent development may “connect” two research strands through a series of cross-fertilizations. The outcome of a cross-fertilization is one or more *interim meta-inferences*, which facilitate the incremental synthesis of the results of each of the two strands and of their interactions. These interim meta-inferences impact the direction of the research project and contribute to an incremental sensemaking of the phenomenon under study until the research question(s) have been addressed. Employing these two concepts, this research design acknowledges and develops the potential of interdependent mixed methods research to lead to stronger insights and conclusions, compared to the prevailing independent conceptualization of concurrent mixed methods research. Interdependent mixed methods research supports the advantages associated with the use of mixed methods (e.g., as discussed in Venkatesh et al., 2013, 2016) and may provide additional benefits. This is because it resolves

the risk of conflicting findings from different research strands: conflicting results are not treated as problematic but rather as an opportunity for cross-fertilization that may steer the research in exploring why conflicting results may have been derived. This can potentially provide richer research insights on the phenomenon under study and justify and document corrections and adjustments in the research methods employed for data collection and analysis.

Given this conceptualization and vocabulary, the interdependent design we propose prompts the research team to regularly revisit their understanding of the phenomenon and proceed accordingly in the design, data collection, and analysis stages of the research strands in a recursive mode. While such iteration is intuitive for experienced researchers, especially in the interpretive qualitative tradition (Klein & Myers, 1999), the mixed methods research literature ignores and practically discourages it, promoting the prevailing research design typologies where iteration does not neatly “fit.” This second aspect of our contribution thus moves beyond the conceptualization of the research *design* and focuses on the research *process*, advocating that it should evolve in a dynamic and iterative fashion. Importantly, this should prompt researchers to *consciously think about this evolution of the research process*, providing guidance for systematically and incrementally exploiting the interaction among two (or more) research strands. Thus, our research design is illustrated as a process in the *flow diagram* we propose, serving as a possible roadmap for this type of research. The flow diagram shows the points where cross-fertilizations and interim meta-inferences may occur and the paths that researchers may follow as a result of these interim meta-inferences. Following this process, the mechanisms through which final meta-inferences are reached are unveiled and explained.

Both the design and process aspects of our contribution, initially inspired by our own engagement with mixed methods research, as discussed in the previous section, have been validated by both junior researchers and experienced colleagues (see Appendix D). The former confirmed the usefulness of our design as a guide for the development and execution of a research plan, while the latter confirmed the relevance of cross-fertilizations and interim meta-inferences, with insights from their published mixed methods research work. They acknowledged the occurrence of iteration and recursion across research strands, even though this was not necessarily realized or documented. They also acknowledged the complexity of the research process as depicted in our flow diagram, which is nonetheless closer to the way research actually happens and therefore allows the presentation of research stories that do not fit linear research accounts but may lead to richer insights.

This feedback leads to a third aspect of our contribution, which concerns the *documentation of interdependent mixed methods research*. We proposed a *table template* for recording details on each cross-fertilization and interim meta-inference. This template “zooms in” on the interactions depicted in the DNA helix (cross-fertilization) and the corresponding interim meta-inferences. In Section 3 and Appendix C, we provide examples and full documentation, respectively, to illustrate how we have used this tool in our own work. Such documentation can assist in demonstrating the validity of research results, as it is possible to see how conclusions were incrementally built and how each research strand contributed to them. We do not expect that such extensive documentation would necessarily appear in a publication. However, we envision that it can serve as a helpful tool for researchers engaged in this type of research, allowing them to keep track of the interaction across strands, the research progression, and the reasons why certain research directions were followed and how certain interim or final meta-inferences were reached, and enabling them to document their research decisions. Such documentation can also be used selectively by researchers to provide justification for important changes in direction in their research, to document certain research propositions or hypotheses (e.g., when findings in a qualitative strand lead to the identification of constructs or reveal potential correlations worth studying), or to support in-depth accounts of their methodology (e.g., in presenting and defending doctoral work).

Following the review of our threefold contribution to interdependent mixed methods and the conceptual tools that support it (the DNA helix, the flow diagram, and the table template), we move on to present a set of principles for this type of research. These consolidate the characteristics and value of interdependent mixed methods research. We envision that highlighting these characteristics will raise awareness about the potential of such research in the IS research community and lead to a number of practical implications for researchers interested in pursuing mixed methods research.

5.3 Principles for Interdependent Mixed Methods Research

In this section, we bring together the lessons learned from this research and the implications of our proposed research design in the form of five principles that can be used to extend the understanding and application of interdependent mixed methods in IS research. Building on the cross-fertilization concept, Principles 1 to 3 invite researchers to be dialectical, open, and disciplined in conducting interdependent mixed methods research, while Principles 4 and 5 suggest that interim meta-inferences can be drawn incrementally when researchers are reflective and recursive in their work (Figure 10). We discuss each principle in detail in the following paragraphs.

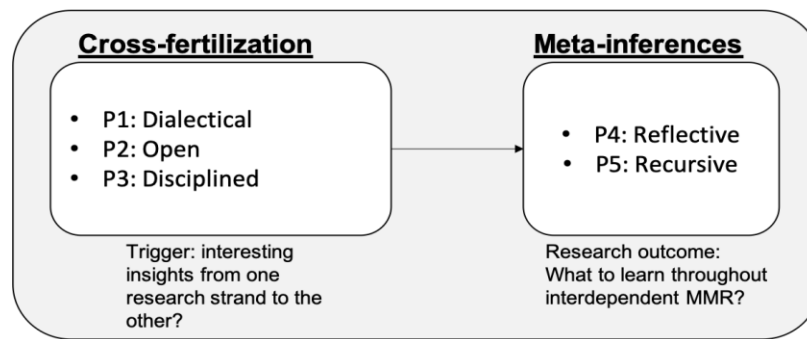


Figure 10. Principles (P) for Interdependent Mixed Methods Research

Principle 1—Dialectical: The influence of each research strand on the other can be ongoing and needs to be acknowledged and recorded.

This principle implies a continuous conversation between two (or more) research strands. The authors of mixed methods papers that we interviewed (cf. Appendix D) confirmed that this is something that occasionally happens as their research unfolds, even though it is not clearly shown in their written work. Both experienced researchers, as well as junior respondents, found cross-fertilization to be a valuable concept, as it prompted and guided a constructive dialogue between the two strands, replicating the antiparallel design of the DNA helix analogy.

As cross-fertilization is accommodated at all stages, in interdependent designs, researchers should allow information to freely move from one research strand to the other, regardless of the research stage. For example, the initial findings of a qualitative strand (at the data collection stage) may contribute to formulating the hypotheses of a quantitative strand (research design stage). In this way, the insights extracted so far in one research strand may contribute to the redrafting of the researcher’s understanding and hence have an impact on how the following steps of the other research strand are formulated. Interdependent designs require that researchers be inclusive and combine thoughts and insights from the two (or more) research strands at all stages rather than only in the data analysis and implications stages. This means that at any time across the design, data collection, and data analysis lifecycle, researchers should allow cross-fertilization and seek additional insights arising from the other research strand so that they can capitalize on any novel perspectives that might be provided by the other research strand.

Principle 2—Open: The research remains open to accept that the insights of one research strand are likely to affect the understanding in the other research strand to allow for new perspectives and research directions.

This principle suggests that in the process of cross-fertilization, the researcher needs to be open to understanding and considering: (1) what the findings of each research strand are and how these can contribute to the understanding of the phenomenon and (2) how the findings of one research strand may influence (e.g., enhance or challenge) the design and execution of the other research strand. This further suggests that the research plan is not static. Indeed, researchers should consider that the initial research plan may need to be adjusted while the research is in progress. For example, the scope may need to be revisited (e.g., broadened to accommodate emergent insights or inconclusive results or narrowed to abandon concepts or constructs that prove less relevant). While the top-level research question may remain the same, the scope may be refined, or new angles of inquiry or subquestions may arise, as repeatedly happened in our cloud adoption research example. This process may also justify the formulation of new research hypotheses in a quantitative strand or new research propositions in a qualitative strand. Although this is a natural part of research, researchers typically present their research design as something that is defined fully a priori, is “neat” and remains stable over the course of the research project in accordance with the prevailing tradition in our publication outlets. Our experience and that of our interviewees suggest that this is not always the case.

Principle 3—Disciplined: Although the research process is to some extent emergent, it is driven by a high-level research objective that invites research to remain ordered and disciplined and leads to a concrete outcome within reasonable time boundaries.

While cross-fertilizations require research strands to be in continuous and open dialogue with each other, research completion requires additional discipline and focus by the researchers. In interdependent research, the researcher is more flexible in making adjustments. Indeed, this type of research invites researchers to build on initial or unexpected research findings as they

arise from the intermediate findings of their ongoing research, as discussed earlier. However, this entails the risk of everlasting research in which iterative research cycles endlessly build on one another. This concern was indeed raised in our interviews by our junior respondents, who may have lacked the experience to define what is “good enough” for a research project. Hence, the use of interdependent design relies on the research inquiry being driven by a well-defined research question (although modifications or interesting subquestions may arise) and the research project being bounded by order and balance in the effort allocated to each research strand. This will ensure that the researchers remain focused on the research objective so that they can reach concrete results within a reasonable time frame.

Principle 4—Reflective: Each time that cross-fertilization occurs, it motivates the research to progress in depth—the researchers are expected to reflect on their findings so that they can decide, on the one hand, what is useful and completed and, on the other hand, what is open or conflicting across the two strands (or diverse studies) and thus merits further research.

The interdependent design requires researchers to maintain a reflective attitude throughout the research lifecycle. Each time a cross-fertilization occurs, researchers need to think about their current findings, to decide what is useful, what is complete, and what merits further investigation. Novel, unexpected, or contradictory results are often the ones that researchers should reflect on. Drawing on our cloud adoption example, in Cross-Fertilization 3, the quantitative study showed that remote access is a significant factor influencing the decision to adopt. This finding was novel and unexpected, which stimulated an interest in exploring the role and the positioning of this factor in the decision-making process in the qualitative research strand, thus resulting in a new meta-inference. Along the same lines, researchers conducting interdependent design should be reflective across all stages of the research so that they are able to provide a more informative explanation of how and why their findings and research design unfolded in a particular direction. We argue that this information is particularly valuable, especially for junior researchers, as it can provide them with a detailed overview of how the research process might organically shift towards a certain direction and how meta-inferences can be derived.

Principle 5—Recursive: As long as interim meta-inferences can be derived, the research inquiry needs to continue; existing knowledge and the research model are revisited, and a recursion is implied until the final meta-inferences have been reached.

Interdependent designs assume that research is recursive. Triggered by cross-fertilization, the researchers’ understanding is redrafted and (interim) meta-inferences are derived, thereby implying the need for a new research cycle. As such, the recursion in interdependent mixed methods research enhances the fully integrated mixing strategy as presented by Tashakkori and Teddlie (2003). The idea of recursion is not new to research. Grounded theory advocates, for example, explicitly acknowledging iterations in data analysis for theory development (Charmaz, 2014; Levina, 2021). In a similar vein, Lindberg (2020) suggests abductive inquiry as “an iterative alternation between discovery and justification” (p. 95) to guide the combination of qualitative research with machine pattern recognition techniques. This approach relates to both the reflective and the recursive principles. In our work, recursion broadly applies to the way in which interim meta-inferences are drawn as a result of cross-fertilizations. As long as the researcher can identify gaps or open questions or finds that the results of a research strand are unexpected or contradictory (i.e., there are such interim meta-inferences), further research will be required, potentially leading to further cross-fertilizations. This would correspond to adding cycles to a research project, going deeper into the research problem and expanding the ways in which it is understood. As soon as this ceases to be the case, the research reaches a point where final meta-inferences can be derived and the research question can be considered to have been adequately addressed. Moreover, we suggest that the concept of recursion, as discussed above, aligns with the hermeneutic circle (Klein & Myers, 1999). Just like the iterative process of deriving interim meta-inferences prompts further inquiry, the hermeneutic circle involves a continuous back-and-forth movement between understanding and interpretation. In recognizing these similarities, we reiterate our proposition that mixed methods research is not a linear path but rather a dynamic, evolving journey where insights and understanding deepen through repeated engagement with the subject matter.

Table 5 proposes some practical guidelines for researchers thinking about interdependent research, that are directly related to the principles presented. Although several of these would apply to any research project, we further encourage researchers to exploit the flow diagram and the concepts developed in our approach to manage the additional complexity of two or more research strands.

Our design is scalable. On the one hand, the principles we propose can be applied to research that uses two or more research strands, regardless of whether these are qualitative, quantitative, computationally intensive, multimethod, or other. What matters is incremental knowledge building and exploiting interim meta-inferences that result from cross-fertilizations.

Table 5. Practical Guidelines for Operationalizing the Principles

Recommendation for researchers and research teams	Related principles
Hold regular meetings (or present research-in-progress in workshops with a broader audience, as in a research seminar), to discuss ideas, progress, interim findings, puzzling or inconclusive results. Share, listen, expect to be challenged.	Dialectical Open Reflective
Build research teams with collaborators with expertise in diverse research methods to facilitate the undertaking of mixed methods project, as they approach a research problem from different angles	Dialectical
Proactively seek possible cross-fertilizations (“insights of interest to the other strand”) at the start of a research project	Dialectical Open
Ask the questions of the flow diagram: “Insights of interest to the other strand?” and “Has the research question been addressed?” regularly as the research progresses	Dialectical Disciplined Reflective
Look out for gaps, open questions, unexpected or contradictory results throughout the research process	Dialectical Open Recursive
Balance the effort allocated to each research strand (without compromising the needs of different research methods)	Disciplined
Expect several iterations	Open Recursive
Explore possible paths in the flow diagram every time a research step is completed, or a decision point is reached—How could alternative paths influence the research design and interim meta-inferences?	Dialectical Open
Allow time for reflection; this is particularly important at the decision points (the diamonds in the flow diagram). Reflection time should not be infinite—ensure that decisions are taken in a timely manner to keep the project moving forward	Open Disciplined Reflective
Keep a record of derived interim meta-inferences, e.g., using the template presented in Tables 2 in Section 3.4 or C5 in Appendix C (Note that this can also serve as a useful log and memo of the research progress for self-reference)	Dialectical Disciplined
Manage the process closely (using project management techniques and insights from agile development approaches) to ensure closure is reached	Disciplined Recursive
List interim meta-inferences together to monitor overall progress—Is cross-fertilization leading to more novel insights or is saturation reached? How close is the project to addressing the research question?	Disciplined Reflective Recursive

On the other hand, we envisage that interdependent research could be extended to guide research projects or programs of a larger scale. Such research programs may involve remote, multidisciplinary teams within a research program (e.g., working in different “work packages”) that are combined once they have been completed (e.g., in a separate “work package” that brings the research strands together). This is in line with the prevailing concurrent mixed methods research design, where studies run independently of each other. We invite researchers engaged in such research programs to experiment with our interdependent design to confirm its relevance and value in such complex settings.

6 Conclusion

Our interdependent design unpacks concurrent research methods and embraces their inherent complexity. It provides a more thorough explanation of what happens within each strand and across strands. This type of research is rewarding because it combines

qualitative and quantitative or other research strands, allowing them to grow together and lead, through a series of interim meta-inferences, to richer insights and a deeper understanding of the phenomenon under study. Our proposed design enables researchers to make more informed decisions for the course of their research and include additional insights that emerge from the cross-fertilizations and resulting meta-inferences, presenting research “stories” that would have otherwise remained untold. From the reader’s perspective, this research design allows a more detailed understanding of how the research was executed in practice. For junior researchers, exposure to such richer research accounts can be particularly valuable, allowing them to appreciate and prepare for the complexity of the research process.

The proposed interdependent design includes three conceptual tools: the DNA helix analogy, a flow diagram, and a table template. The DNA helix analogy helps describe how the researcher’s thinking on a research project unfolds and develops, contributing to

the simplification of a rather complex process. Therefore, it provides the opportunity to learn not just about the outcome of a research project but to better understand and critique the research process itself. The flow diagram, in turn, can serve as a roadmap offering practical guidance for conducting interdependent mixed methods research, whereas the table template can help in documenting cross-fertilizations and interim meta-inferences. Drawing on our research on cloud adoption, we demonstrate how these tools can be operationalized, showing how and when cross-fertilizations occur and what may be the (interim) meta-inferences, thereby offering a more accurate, comprehensive, and pragmatic view of the research process. Using the insights of colleagues, we validated this research design and drew lessons, in the form of five principles for this type of research.

Encouraging a research team to come together often, sharing and discussing difficulties and puzzling or inconclusive results arising in one strand and exploring

their implications and interpretations from the perspective of the other strand can enable researchers to present the “actual” story of research, giving more space to the voices of respondents in empirical research so that richer insights can be derived and the practical impact of IS research can be more significant. We predict that this will empower researchers to become more inclusive in the use of different methods and insights, as well as more comprehensive, as they will provide more details on “how” the research unfolded. As a result, they will be able to provide a more accurate and transparent overview of their research journey. This overview may be closer to what we know happens in research practice: a constant rethinking and redrafting of our understanding of the field. Sharing an overview of how a mixed methods research project is conducted is expected to be extremely useful, especially for junior scholars, and will encourage them to embark on their own mixed methods research.

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Appendix A: Sequential and Concurrent Mixed Methods Papers

In order to review the use of mixed methods in high-quality research in information systems, we looked in recent papers published in the premier Information Systems publication outlets. We searched for papers published in a five-year period (01/2017-01/2022) in ABS 4* IS journals (Information Systems Research, Journal of the Association of Information Systems, Management Information Systems Quarterly). We used the search engines of these journals using the words “mixed-methods,” “mixed-method,” “mixed methods,” “mixed method.” The search process returned 396 papers. To identify mixed methods papers from this pool and ensure consistency with earlier research, we started employing the same search criteria as Venkatesh et al. (2013), namely, that the study must be empirical, employing both quantitative and qualitative methods of data collection and that both quantitative and qualitative data must be analyzed and presented. These criteria reflect the traditional composition of mixed methods papers that combine, sequentially or concurrently, two distinct strands, one qualitative and one quantitative. However, as the wider use of digital technologies has led to abundance of data coming from many different data sources, we are increasingly seeing the application of computational approaches (e.g., Vaast et al., 2017), analytical models (e.g., Sahaym et al., 2022¹¹), and various other methods seeking to extract new knowledge from existing data or generate new data published in IS journals. These novel approaches cannot be described as representing a purely qualitative or purely quantitative worldview. We thus extended the search criteria of our literature review to include empirical studies that combined different worldviews but did not necessarily use qualitative and quantitative types of data or data collection methods. We then studied the papers found and reviewed their methodology section to exclude editorials, papers providing methodological guidelines, and papers not actually using mixed methods.

This process led to the identification of 32 empirical mixed methods studies. Nine of these papers are concurrent and particularly relevant to our research aim. For this reason, in Table A1 we provide details, where available, related to the research approach, purpose, mixing strategy, data collection and analysis strategies, as well as information on how meta-inferences were achieved. We also provide indicative supporting quotes.

Table A1. Analysis of Concurrent Mixed Methods Papers (cf. Section 2)

No	Paper	Mixed methods approach (where strands of research include multistrand design and temporal orientation is concurrent—explicitly or implied)
		<p>For each paper, we provide evidence of the following:</p> <p><i>Authors’ description of the research approach:</i> how the authors describe their approach, where clearly stated</p> <p><i>Purpose of mixed methods’ use</i> (where clearly stated): e.g., completeness, complementarity, developmental, expansion, corroboration/confirmation, compensation, diversity (Zachariadis et al., 2013, p. 865)</p> <p><i>Mixing strategy:</i> how insights were shared or analyses were combined across research strands.</p> <p><i>Data collection strategies—nature of data and methods used</i></p> <p><i>Data analysis strategies:</i> how data were analyzed</p> <p><i>How are meta-inferences achieved:</i> how the authors reached conclusions, either interim or final</p>
1	<p>Haki, K., & Legner, C. (2021) The Mechanics of enterprise architecture principles. <i>Journal of the Association for Information Systems</i>, 22(5), 1334-1375.</p>	<p><i>Authors’ description of the research approach:</i> “a mixed methods exploratory research design” (p. 1340)</p> <p><i>Purpose of mixed methods’ use:</i> unclear</p> <p><i>Mixing strategy:</i> “Instead of transcribing each interview as a separate document, we reconciled the interview material with the secondary data and undertook one comprehensive case write-up per case company.” (p. 1343)</p> <p><i>Data collection strategies—nature of data and methods used:</i> “literature review, an expert study, and case studies” (p.1340)</p> <p><i>Data analysis strategies:</i> “Following the steps set out by Eisenhardt (1989), the data analysis was structured into early analysis and coding, within-case analysis, and cross-case analysis.” (p. 1340)</p> <p><i>How are meta-inferences achieved:</i> meta-inferences during transcription and afterwards, as there was a cross-case analysis</p>

¹¹ We included the paper of Sahaym et al. (2022) in our sample, even though it was slightly outside the time frame of our search, as a helpful example acknowledging how research conclusions are drawn incrementally and also because it enriched the repertoire of mixed-methods studies appearing in our sample.

2	<p>Jenkin, T. A., Chan, Y., & Sabherwal, R. (2019). Mutual understanding in information systems development: Changes within and across projects. <i>MIS Quarterly</i>, 43(2),649-671.</p>	<p><i>Authors' description of the research approach:</i> “longitudinal embedded mixed methods design that combines qualitative and quantitative methods, and a theory-building approach that combines deduction and induction”; “longitudinal embedded mixed methods design, conducting exploratory quantitative analyses in a primarily qualitative study” (p. 664)</p> <p><i>Purpose of mixed methods' use:</i> triangulation (p. A4)</p> <p><i>Mixing strategy:</i> “We use quantitative analyses to explore the data and qualitative analyses to develop a rich understanding.” (p. 654)</p> <p><i>Data collection strategies—nature of data and methods used:</i> 10-year case study data (three intensive waves of onsite interview panel data arising from the interviews)</p> <p><i>Data analysis strategies:</i> “overlapping data collection and analysis” (p. 655); “Data collection and analyses were iterative” (p. 655)</p> <p><i>How are meta-inferences achieved:</i> “We combine deductive and inductive theory building approaches.” (p. 654); “Data collection and analyses were iterative.” (p. 655); “The qualitative analyses provide more nuanced and richer insights” (p. 657); “We considered the rich insights revealed by the qualitative analyses in light of the initial model, the literature, and the results of the exploratory quantitative analyses.” (p. 657)</p>
3	<p>Jiyong P., Min-Seok P., Junetae K., & Byungtae L. (2021). The deterrent effect of ride-sharing on sexual assault and investigation of situational contingencies. <i>Information Systems Research</i> 32(2),497-516.</p>	<p><i>Authors' description of the research approach:</i> “this study employs a mixed methods” (p. 502)</p> <p><i>Purpose of mixed methods' use:</i> “complement each other” (p. 501)</p> <p><i>Mixing strategy:</i> unclear</p> <p><i>Data collection strategies—nature of data and methods used:</i> “macrolevel quasi-experiment with microlevel spatiotemporal analyses” (p. 501)</p> <p><i>Data analysis strategies:</i> qualitative inferencing quantitative</p> <p><i>How are meta-inferences achieved:</i> limited mixing at the end</p>
4	<p>Jussupow, E., Spohrer, K., Heinzl, A., & Gawlitz, J. (2021) Augmenting medical diagnosis decisions? An investigation into physicians' decision-making process with artificial intelligence. <i>Information Systems Research</i> 32(3),713-735</p>	<p><i>Authors' description of the research approach:</i> “inductive approach in an experimental setting” (p. 717)</p> <p><i>Purpose of mixed methods' use:</i> triangulation</p> <p><i>Mixing strategy:</i> unclear</p> <p><i>Data collection strategies—nature of data and methods used:</i> experimental data, which included interviews, survey, think-aloud data—all methods included in one study (experiment), quant is leading</p> <p><i>Data analysis strategies:</i> unclear</p> <p><i>How are meta-inferences achieved:</i> unclear</p>
5	<p>Li, X., Rai, A., & Krishnan, G. (2020). Designing cost-effective telemedicine camps for underprivileged individuals in less developed countries: A decomposed affordance-effectivity framework. <i>Journal of the Association for Information Systems</i>, 21(5), 1279-1312.</p>	<p><i>Authors' description of the research approach:</i> Authors do not refer to their study as mixed method.</p> <p><i>Purpose of mixed methods' use:</i> unclear</p> <p><i>Mixing strategy:</i> unclear</p> <p><i>Data collection strategies—nature of data and methods used:</i> survey + teleconsultation video archives (same telecamps for both datasets)</p> <p><i>Data analysis strategies:</i> “We applied both qualitative and quantitative methods for data analysis (ordinary least squares [OLS] regression, process analysis, and nonparametric statistics).” (p. 1281)</p> <p><i>How are meta-inferences achieved:</i> Meta-inferences generated after the two streams analysed the data separately.</p>
6	<p>Sahaym, A., Vithayathil, J., Sarker, S., Sarker, S., & Bjorn-Andersen, N. (2022). Value destruction in information technology ecosystems: A mixed-method investigation with an interpretive case study and analytical modeling. <i>Information Systems Research</i>, 34(2), 508-531.</p>	<p><i>Authors' description of the research approach:</i> “iterative mixed method study” (p. 3); “unconventional mixed methods study” (p. 22)</p> <p><i>Purpose of mixed methods' use:</i> developmental and expansion (develop theoretical understanding): “triangulation approach” (p. 21),</p> <p><i>Mixing strategy:</i> “concurrent triangulation approach (Venkatesh et al. 2013) enabled by the hermeneutic circle” (p. 21)</p> <p><i>Data collection strategies—nature of data and methods used:</i> theoretical development of analytical models (game theoretic approach p. 3) + qualitative, interpretive case study</p> <p><i>Data analysis strategies:</i> Qualitative data are used to provide “breakdowns” to quantitative models.</p> <p><i>How are meta-inferences achieved:</i> interim meta-inferences every time there is a breakdown: e.g., “Clearly, the evidence in the chosen strips is not consistent with Schema 1 that suggests cooperation, and this highlights a need for additional theorizing.” (p. 9)</p>

7	<p>Seymour, M. Yuan, L., Dennis, A., & Riemer, K. (2021). Have we crossed the uncanny valley? Understanding affinity, trustworthiness, and preference for realistic digital humans in immersive environments. <i>Journal of the Association for Information Systems</i>, 22(3), 591-617.</p>	<p><i>Authors' description of the research approach:</i> "concurrent monostrand mixed methods approach" (p. 596) <i>Purpose of mixed methods' use:</i> complementarity (p. 596) <i>Mixing strategy:</i> unclear <i>Data collection strategies—nature of data and methods used:</i> "qualitative observations, qualitative interviews, and a quantitative survey to answer the research questions" (p. 596) <i>Data analysis strategies:</i> The dataset arising from each study was analyzed separately. <i>How are meta-inferences achieved:</i> Meta-inferences arising from the studies are explicitly identified after the results of each study have been analyzed individually.</p>
8	<p>Slavova, M., & Karanasios, S. (2018). When institutional logics meet information and communication technologies: Examining hybrid information practices in Ghana's agriculture. <i>Journal of the Association for Information Systems</i>, 19(9), 775-812.</p>	<p><i>Authors' description of the research approach:</i> "Our approach follows Venkatash et al's. (2013) recommendations on mixed methods research because we are interested in synthesizing data (e.g., interviews and surveys) aligned with different ontological and epistemological positions." (p. 782) <i>Purpose of mixed methods' use:</i> "to gain complementary data about the same phenomenon (Soffer & Hadar, 2007), and to achieve data completeness by ensuring that a rich and comprehensive picture can arise" (p. 783) <i>Mixing strategy:</i> "The analysis was undertaken in three stages, which integrated our qualitative and quantitative data." (p.785) <i>Data collection strategies—nature of data and methods used:</i> "In-depth qualitative interviews, focus groups, observations, and detailed secondary quantitative data" (p. 775) <i>Data analysis strategies:</i> "The qualitative and quantitative data were analyzed in parallel to expand and validate our findings. This involved incorporating into the findings diverse and opposing views from the data (bracketing), as well as developing a consensus between the qualitative and quantitative data where possible (bridging)." (p. 785) <i>How are meta-inferences achieved:</i> "Insights from both analyses were amalgamated to develop our understanding. We verified the resulting meta-inferences and established narrative by undertaking a mixed methods validation (Teddlie & Tashakkori, 2009) approach not only added validity to our understanding (Venkatesh et al., 2013) but also helped to overcome some qualitative field-research challenges (Myers & Newman, 2007)." (p. 785)</p>
9	<p>Vaast, E., Safadi, H., Lapointe, L., & Negoita, B. (2017). Social media affordances for connective action: An examination of microblogging use during the Gulf of Mexico oil spill. <i>MIS Quarterly</i>, 41(4),1179-1205.</p>	<p><i>Authors' description of the research approach:</i> "mixed methods design focused on the use of microblogging during the Gulf of Mexico oil spill of 2010." <i>Purpose of mixed methods' use:</i> "complementarity and diversity; expansion; compensation" (p. 1187, following Zachariadis et al., 2013) <i>Mixing strategy:</i> unclear <i>Data collection strategies—nature of data and methods used:</i> social media data (microblog posts [i.e., tweets]) <i>Data analysis strategies:</i> concurrent mixed; quantitative cluster analysis; qualitative analysis; quantitative analyses; "Quantitatively, we engaged in cluster, temporal, and network motifs analyses of tweeting behavior." (p. 1186) <i>How are meta-inferences achieved:</i> Meta-inferences generated at the end, the results of qual and quant are mixed; "Quantitative cluster analysis to uncover different clusters of feature use; qualitative analysis to understand the roles these clusters played in connective action. Quantitative analyses to systematically apprehend all collected data regarding the CAEs (connective action episodes); qualitative analyses to bring meaning holistically to this systematic apprehension of the CAEs. Mixed methods to apprehend the nature of interdependence among roles in CAEs and to infer and qualify the nature of affordances of microblogging associated with this interdependence." (p. 1187)</p>

The remaining 23 papers identified in our search (listed in Table A2) followed a sequential research design, with variations in the relative dominance of one strand or another and in the sequence (one or more qualitative studies followed by one or more quantitative studies or vice versa).

Table A2. Sequential Mixed Methods Papers Identified

<ol style="list-style-type: none"> 1. Anderson, E. G., Jr., Chandrasekaran, A., Davis-Blake, A., & Parker, G. G. (2018) Managing distributed product development projects: Integration strategies for time-zone and language barriers. <i>Information Systems Research</i>, 29(1), 42-69. 2. Califf, C. B., Sarker, S., & Sarker, S. (2020). The bright and dark sides of technostress: A mixed-methods study involving healthcare IT, <i>MIS Quarterly</i>, 44(2), 809-856. 3. Hahn, J., & Lee, G. (2021). The complex effects of cross-domain knowledge on IS development: A simulation-based theory development, <i>MIS Quarterly</i>, 45(4), 2023-2054. 4. Harrison, A. (2018). The effects of media capabilities on the rationalization of online consumer fraud. <i>Journal of the Association for Information Systems</i>, 19(5), 408-440. 5. Hukal, P., Henfridsson, O., Shaikh, M., & Parker, G. (2020). Platform signaling for generating platform content, <i>MIS Quarterly</i>, 44(3), 1177-1205. 6. Koutsikouri, D., Lindgren, R., Henfridsson, O., & Rudmark, D. (2018). Extending digital infrastructures: A typology of growth tactics. <i>Journal of the Association for Information Systems</i>, 19(10), 1001-1019. 7. Leung, A. C. M., Santhanam, R., Kwok, R. C., & Yue, W.T. (2022) Could gamification designs enhance online learning through personalization? Lessons from a field experiment. <i>Information Systems Research</i>, 34(1), 27-49. 8. Li, M., Tan, C.-H., Wei, K.-K., & Wang, K. (2017). Sequentiality of product review information provision: An information foraging perspective. <i>MIS Quarterly</i>, 41(3), 867-892. 9. Lindberg, A. Majchrzak, A., & Malhotra, A. (2022). How information contributed after an idea shapes new high-quality ideas in online ideation contests. <i>MIS Quarterly</i>, 46 (2), 1195-1208 10. Moeini, M., & Rivard, S. (2019). Responding—or not—to information technology project risks: An integrative model, <i>MIS Quarterly</i>, 43(2), 475-500. 11. Salo, M., Makkonen, M., & Hekkala, R. (2020). The interplay of IT users' coping strategies: Uncovering momentary emotional load, routes, and sequences. <i>MIS Quarterly</i>, 44(3), 1143-1175. 12. Sarkar, S., Vance, A., Ramesh, B., Demestihis, M., & Wu, D. T. (2020). The influence of professional subculture on information security policy violations: A field study in a healthcare context. <i>Information Systems Research</i>, 31(4), 1240-1259. 13. Sarker, S., Ahuja, M., Sarker, S. (2018) Work-life conflict of globally distributed software development personnel: An empirical investigation using border theory. <i>Information Systems Research</i>, 29(1), 103-126. 14. Tarafdar, M., & Ray, D. K. (2021) Role of social media in social protest cycles: A sociomaterial examination. <i>Information Systems Research</i>, 32(3), 1066-1090. 15. Trieu, V., Burton-Jones, A., Green, P., & Cockcroft, S. (2022). Applying and extending the theory of effective use in a business intelligence context, <i>MIS Quarterly</i>, 46(1), 645-678. 16. Venkatesh, V., Sykes, T. A., Chan, F. K. Y., Thong, J., & Hu, P.J. (2019). Children's Internet addiction, family-to-work conflict, and job outcomes: A study of parent-child dyads. <i>MIS Quarterly</i>, 43(3), 903-927. 17. Venkatesan, S., Valecha, R., Yaraghi, N., Oh, O., & Rao, H. R. (2021). Influence in social media: An investigation of tweets spanning the 2011 Egyptian Revolution. <i>MIS Quarterly</i>, 45(4), 1679-1714. 18. Watson, R. T., Dawson, G., Boudreau, M., Li, Y., Zhang, H., Huong W., & Aljabri, I. M. (2019). Constraining opportunism in information systems consulting: A three nation examination. <i>Journal of the Association for Information Systems</i>, 20(7). 19. Wu, J., Huang, L., & Zhao, J. L. (2019). Operationalizing regulatory focus in the digital age: Evidence from an e-commerce context. <i>MIS Quarterly</i>, 43(3), 745-765. 20. Wunderlich, P., Veit, D., & Sarker, S. (2019). Adoption of sustainable technologies: A mixed-methods study of German households. <i>MIS Quarterly</i>, 43(2), 673-691. 21. Xiao, X., Lindberg, A., Hansen, S., & Lyytinen, K. (2018). "Computing" requirements for open source software: A distributed cognitive approach. <i>Journal of the Association for Information Systems</i>, 19(12). 22. Xiao, X., Sarker, S., Wright, R. T., & Mariadoss, B. J. (2020). Commitment and replacement of existing SaaS-delivered applications: A mixed-method investigation. <i>MIS Quarterly</i>, 44(4), 1811-1857. 23. Zhang, X. (2017). Knowledge management system use and job performance: A multilevel contingency model. <i>MIS Quarterly</i>, 41(3), 811-840.
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Appendix B: Critical Realism

A philosophical problem associated with the adoption of mixed methods research is the possibility of integrating different paradigms. The combination of different paradigms brings up contradictions and inconsistencies. Kuhn refers to this incompatibility as the incommensurability of paradigms (Kuhn, 1996). In the social sciences, some have rejected the plausibility of mixed methods just on the basis of the incommensurability of paradigms argument (e.g., Lincoln & Guba, 1985). The rejection of mixed methods based on the incompatibility of paradigms, especially when combining qualitative and quantitative methods, is founded on epistemological and ontological inconsistencies. On the one hand, quantitative researchers have embraced a positivist ontology in which they assume the existence of immutable laws that can be learned objectively, which implies a naturalistic epistemology. Qualitative researchers, on the other hand, affirm that knowledge is socially constructed and some of them, the most radical, would reject the plausibility of immutable laws, specifically when referring to social sciences.

Some mixed methods advocates have vindicated mixed methods adopting a pragmatist position (e.g., (Feilzer, 2010; Greene, 2008; Morgan, 2007). Pragmatism is a philosophical strand of thinking that started in the USA in 1870 (Dewey, 1969a, 1969b; James, 1981; Peirce, 1992 1999). Very recently, pragmatism has been reinvigorated through the works of Brandom, Putnam, and Rorty (Brandom, 2011; Putnam, 1997; Rorty, 1980). The core of pragmatism is that scientific theories should be evaluated according to their practical consequences. For pragmatists, then, the validity of a mixed methods inquiry depends not on epistemological and ontological consistencies but on the value and utility of the findings. The pragmatism perspective supports the case of mixed methods in IS inquiry because it directs us to the value of the findings and not to the adherence to an accepted design (Venkatesh et al., 2016; Venkatesh et al., 2013).

Despite the persuasive arguments in favor of pragmatism, some mixed methods researchers have been reluctant to adopt such a position. In this sense, Maxwell and Mittapalli (2010) claim that the flaw in vindicating mixed methods through pragmatism is that it underestimates the influence that philosophical assumptions have on research. For Maxwell and Mittapalli, ontological and epistemological assumptions cannot be dismissed as they influence researchers' actions and objectives. As mentioned above, a positivist ontology assumes the existence of laws that determine cause and effect relations, and these can only be known through experiments and statistical techniques. If this position is taken seriously, researchers will dismiss any qualitative technique that considers knowledge as subjective and that does not recognize objective laws. Likewise, some radical qualitative researchers would reject the possibility of objective, verifiable knowledge that reveals laws. Given this tension, some researchers propose critical realism as a philosophical foundation that not only alleviates the tension but also, and most importantly, potentiates the strengths of positivistic and interpretive approaches.

Mingers (2004) proposes critical realism as a coherent and consistent underpinning philosophy for conducting research in information systems, as it solves the tensions between interpretivists and positivists. For the purposes of our paper, it is relevant to emphasize that Mingers does not propose critical realism as a method but as an underpinning philosophy to reconcile tensions between different paradigms. This is a pertinent clarification, as some IS researchers have applied critical realism as a method of inquiry (e.g., (Zachariadis, Scott, & Barrett, 2013). For our paper, then, instead of adopting critical realism as a method of inquiry, we embrace it as a philosophical position whose main purpose is to solve epistemological and ontological tensions, as proposed by Mingers.

Appendix C: Detailed Presentation of Cross-Fertilizations and Interim Meta-Inferences in the Cloud Adoption Research Study

In this Appendix we provide a detailed account of our cloud adoption research, discussing in detail the key cross-fertilizations and resulting interim meta-inferences summarized in Section 4. We illustrate the research progress using the flow diagram (Figure 6) and Table 2 for each cross-fertilization. At the end of this presentation, we provide a table presenting an overview of all interim meta-inferences, which shows the incremental progression of our research conclusions.

Cross-Fertilization 1

The first set of interviews (qualitative strand) enhanced the literature-based perception of the research team of the factors influencing cloud adoption decisions. The interviews indicated that cost-reduction, security concerns, and remote access were factors relevant to cloud adoption decisions. Cost-reduction and security concerns were also found in the extant literature as factors affecting cloud adoption, whereas remote access was not discussed. The interviews also indicated that the decision-making process for cloud adoption involves multiple stakeholders (IT department, management staff, actual users). Meanwhile, the preparation for a survey on the factors influencing cloud adoption decisions was underway (quantitative strand). At the start, this was solely informed by the extant literature where key factors include security concerns, cost reduction, relative advantage, “beliefs” about the cloud, etc. The existing literature also showed that earlier research focused on top management rather than the beliefs of actual users. The insights derived from the pilot interviews caused the research team to redraft their perceptions of which factors were most relevant to study. In this cross-fertilization, the preliminary findings of the qualitative strand informed the quantitative strand. Following this cross-fertilization, the resulting meta-inference was a research model, encompassing the constructs and hypotheses to study through Survey 1 (see Table C1). The results of the first interviews also indicated that the decision-making process often involves a variety of stakeholders, including technical executives, leading management executives, as well as users from the department of the organization in which the service will be deployed. However, the existing literature showed limited research work on investigating cloud adoption from the users’ perspective. For this reason, the survey was targeted to actual users of a specific department of a large organization (the human relations department in this case, to exploit our access to respondents) and thus the questions were directed towards cloud adoption in a specific sector. Thus, a meta-inference following Cross-Fertilization 1 was also related to the target audience for the survey.

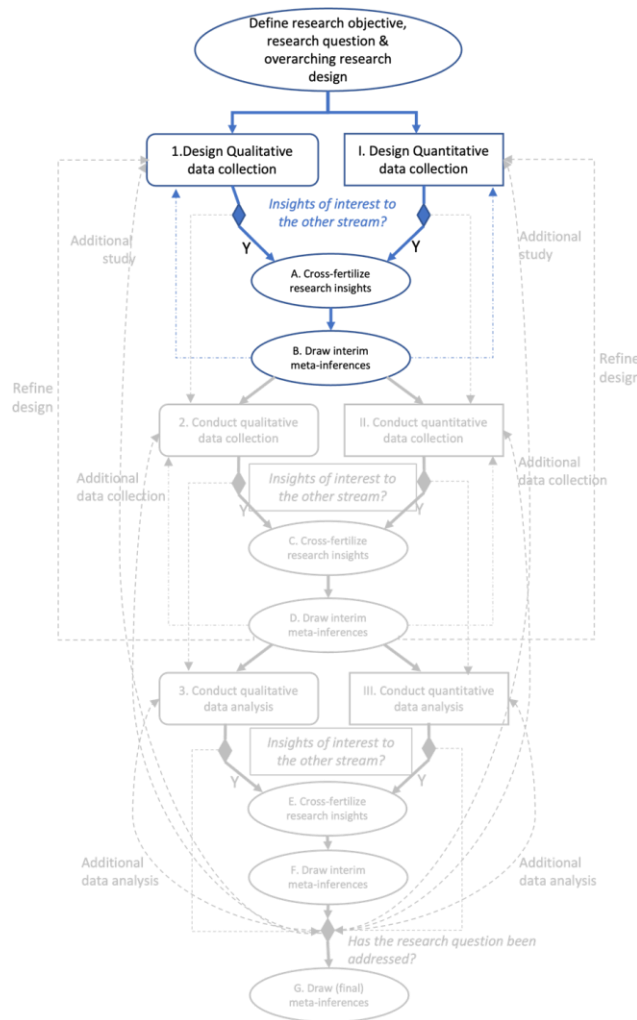


Table C1. Cross-Fertilization 1: From the Qualitative Strand to the Quantitative Strand

Qualitative research strand	Cross-fertilization	Quantitative research strand
<p>[1. Design qualitative data collection]</p> <p>Indicative findings from pilot phase: Factors influencing cloud adoption:</p> <ul style="list-style-type: none"> • cost reduction and security concerns (in line with the literature) • remote access (in addition to the literature) <p>Decision process to adopt cloud: involves multiple stakeholders (IT department, management staff, actual users)</p>	<p>The results of the qualitative strand inform the hypotheses formulation of the quantitative strand (which factors from the literature to survey; which additional factors to consider) and the target audience of the survey (users can offer an alternative/ complementary perspective on cloud adoption)</p>	<p>[I. Design quantitative data collection]</p> <p>Literature:</p> <ul style="list-style-type: none"> • security concerns, cost reduction, relative advantage, ‘beliefs’ about the cloud, etc. are factors influencing cloud adoption • research focuses on top management and does not address the beliefs of actual users
<p>Interim meta-inferences</p> <p>[Survey 1: hypotheses and research model]: (which factors from the literature to survey; which additional factors to consider)</p> <p>Key constructs:</p> <ul style="list-style-type: none"> • cost reduction; security concerns; remote access <p>Hypotheses:</p> <p>H1: Perceived cost reduction positively influences intention to adopt cloud services</p> <p>H2: Perceived remote access positively influences intention to adopt cloud services</p> <p>H3: Security concerns negatively influence intention to adopt cloud services</p> <p>Target audience: cloud users (users can offer an alternative/ complementary perspective on cloud adoption)</p>		

Cross-Fertilization 2 and Cross-Fertilization 3

These cross-fertilizations are presented in detail in the main text (Section 4.2).

Cross-Fertilization 4

In Table C2, insights from the qualitative strand informed the quantitative strand leading to the formulation of hypotheses and research model of Survey 2. The qualitative strand provided indications that despite the plethora of different stakeholders involved in cloud adoption decisions, in each case the process is led by one party, typically the CIO or a top management executive (in the case of organizations without an IT department). It also indicated that the leading decision makers’ innovativeness (personnel innovativeness), as well as the organization’s overall innovativeness (managerial innovativeness), may be additional factors that have an impact on the decision to adopt the cloud in organizations. The results of the qualitative strand also indicated that the context of adoption influences the process followed, even though some organizations might hold a horizontal policy of switching to the cloud. From the interviews, it transpired that the relative advantage of using the cloud in a specific business area may have a significant impact on the cloud adoption decision. Thus, insights from the qualitative strand provided additional information for the hypotheses and research model of Survey 2. In particular, meta-inferences regarded the identification of the two key main concepts, the cloud’s relative advantage in relation to a specific business area and organization’s innovativeness. Driven by the findings of the qualitative study, Survey 2 was targeted towards the leading decision maker of the cloud adoption decision-making process in each organization. Also driven by the insights of the qualitative strand, Survey 2 was designed so that respondents were requested to select a specific business area in which they recently decided to adopt the cloud at the beginning of the survey; then, the questions that followed were asked in the context of the business area selected.

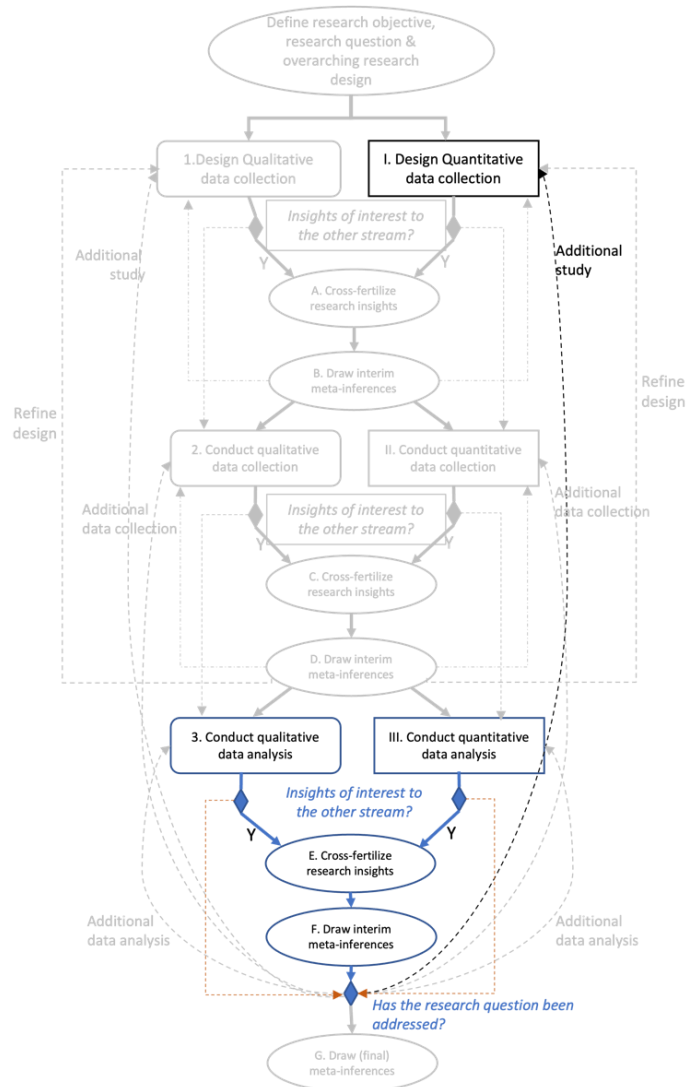


Table C2. Cross-Fertilization 4: From the Qualitative Strand to the Quantitative Strand

Qualitative research strand	Cross-fertilization	Quantitative research strand
<p>[3. Conduct qualitative data analysis]</p> <p>Indicative findings:</p> <ul style="list-style-type: none"> • specific stakeholders lead the cloud adoption decision-making process: the CIO or a top management executive (in organizations without an IT department). • characteristics of the leader of the process such as innovativeness as well as the organization's innovativeness might influence the decision to adopt • cloud adoption is not necessarily a horizontal decision across the whole organization (although it might be driven by a horizontal strategy to adopt cloud); the context of adoption, such as the business application area and the relevant value, influences the decision and the process followed 	<p>The results of the qualitative strand inform the hypotheses formulation of the quantitative strand (which factors from the previous survey, which factors relevant to innovativeness; redefine target audience- the leading decision maker; define context of the survey)</p>	<p>[1. Constructing research model for Survey 2]</p> <ul style="list-style-type: none"> • key constructs: cloud relative advantage (cost reduction, security concerns, remote access) in relation to a specific business area • Hypotheses: <ul style="list-style-type: none"> H1: Perceived cost reduction positively influences intention to adopt cloud in a specific business area H2: Perceived possibility for remote access positively influences intention to adopt cloud in a specific business area H3: Security concerns negatively influence intention to adopt cloud in a specific business area
Interim meta-inferences		
<p>[Survey 2: hypotheses and research model]</p> <ul style="list-style-type: none"> • <i>Additional constructs: organizational innovativeness</i> (managerial innovativeness and personnel innovativeness) • Respondents (cloud decision-makers) invited to select the business area on which they report results (context) • Additional hypotheses: <ul style="list-style-type: none"> H4: Personnel innovativeness positively influences intention to adopt cloud in a specific business area H5: Managerial innovativeness positively influences intention to adopt cloud in a specific business area <p>[Survey 2 issued, targeted to cloud decision-makers]</p>		

Cross-Fertilization 5

Table C3 illustrates the communication of the findings of the quantitative strand to the qualitative strand. At this stage, the results of Survey 2 provided the opportunity to revisit the findings of the qualitative strand, providing ideas for new dimensions of analysis and identifying issues that prompted further analysis of the qualitative insights. The quantitative strand indicated inconsistency in the significance of personnel vs. managerial innovativeness. In contrast to the literature, security concerns were not identified as significant in any of the surveys; cost reduction was not significant in Survey 1, but was significant in Survey 2, and remote access was significant across both surveys (although not acknowledged in the literature). The cross-fertilization from the quantitative to the qualitative strand triggered further analysis of the qualitative data, which showed that personnel innovativeness is vital at the early stages of the cloud adoption decision-making process. The findings of the quantitative research at this stage also led to recoding the data with respect to the cloud's value, revealing in this way that the cloud's benefits are important for the decision to adopt only to the extent that they are aligned with the needs of the particular business area exploring cloud adoption. Further analysis of the interview data also led to the conclusion that security concerns are reduced as decision makers discuss options with peers and local/trusted vendors.

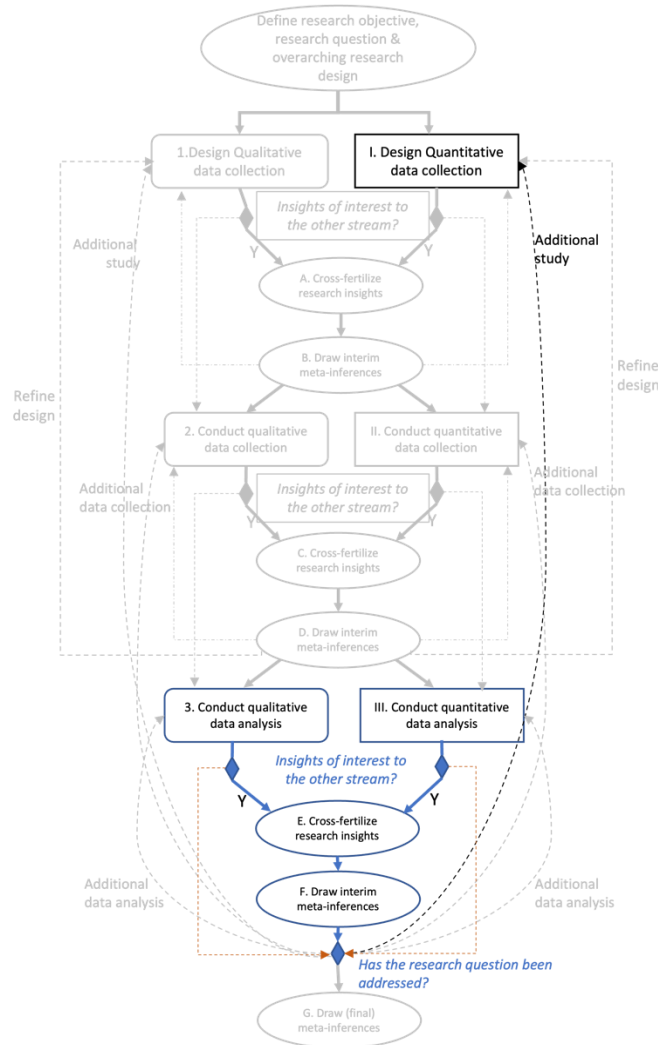


Table C3. Cross-Fertilization 5: From the Quantitative Strand to the Qualitative Strand

Quantitative research strand	Cross-fertilization	Qualitative research strand
<p>[III. Conduct quantitative data analysis, Survey 2: Thinking about unexpected and inconsistent results]</p> <ul style="list-style-type: none"> • Managerial innovativeness not significant, but personnel innovativeness significant • Security concerns not significant, even for CIOs (targeted respondents), inconsistent with existing literature • Remote access is significant across both Surveys (although not highlighted in the literature) 	<p>The results of the quantitative strand provide new dimensions of analysis as well as insights and issues for further analysis in the qualitative strand (understand the positioning of certain factors in the phases of the decision-making process)</p>	<p>[3. Conduct qualitative data analysis]</p> <ul style="list-style-type: none"> • Users might be involved in Phase 2 • Vendors may be actively involved in Phase 2 • The leading decision maker evaluates alternatives and cost is a key aspect • Service cost is part of the leading decision maker’s proposal in Phase 3 • A larger group of executives might be involved in Phase 3 to provide authorization for the decision
<p>Interim meta-inferences</p> <p>[Semi-structured interviews, reanalyze current data thinking about unexpected and inconsistent results]</p> <ul style="list-style-type: none"> • Managerial innovativeness may be more relevant in the last phase of the decision-making process, whereas personnel (including CIO) innovativeness matters throughout the decision-making process. • CIO innovativeness, in particular, is critical during the early phases of the process, as it may determine whether a cloud solution is to be considered or not • Security concerns are reduced as decision makers discuss options with peers and local/trusted vendors in Phase 2 of the decision-making process 		

Cross-Fertilization 6

In Cross-Fertilization 6 (Table C4), the results of the qualitative strand informed the interpretation of the results of the quantitative strand regarding Survey 2. The analysis of the interview data in the qualitative strand showed that the cloud adoption decision-making process is led by the CIO or the CEO or director in SMEs without an IT department. The qualitative results also showed that the decision-making process can be broken down into three phases: (1) building perceptions about the cloud, (2) contextualizing the cloud, and (3) exposing the cloud proposition (Polyviou et al., 2024). Although these phases are all led by the senior decision maker, certain types of stakeholders tend to be involved at different stages. For example, users and vendors might be involved in Phase 2, whereas high-level managerial executives are more likely to be involved in Phase 3 in order to provide authorization for the decision. The results of Survey 2 in the quantitative strand showed that remote access, cost reduction, and personnel innovativeness were significant factors affecting cloud adoption, whereas security concerns and managerial innovativeness were not significant. At the same time, the results of the qualitative strand assisted the interpretation of the results of the quantitative strand. Meta-inferences regarded the personnel and managerial innovativeness constructs, in particular. The significance of personnel innovativeness (i.e., innovativeness of specific individuals responding to the survey) could be explained based on the qualitative findings about the decision makers; specifically, the innovativeness of the leading decision maker (e.g., the CIO in many cases) appears vital for the initiation of the process and the collection of information about the potential adoption from several sources. The limited involvement of other top management executives in Phase 3 might explain why managerial innovativeness (i.e., innovativeness of the whole management of an organization, which is an organizational trait) is not significant. Similarly, regarding cost-reduction, based on the qualitative findings, we can conclude that the leading decision maker also evaluates costs in Phases 1 and 2 so that a proposal can be made at Phase 3 of the process. These insights provided additional justification for the significance of the cost reduction factor. Findings of the qualitative strand also clarified that the process involves the cross-checking of information from different sources, retrieving referrals from vendors and piloting the service. These findings assisted us in interpreting the nonsignificance of the security concerns construct.

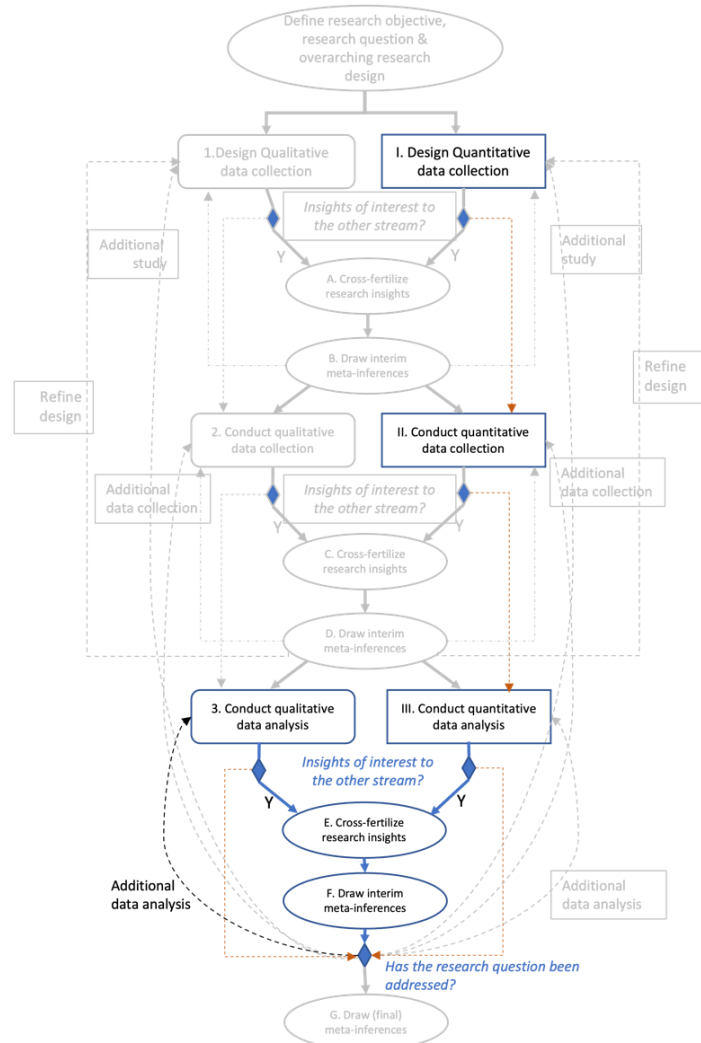


Table C4. Cross-Fertilization 6: From the Qualitative Strand to the Quantitative Strand

Qualitative research strand	Cross-fertilization	Quantitative research strand
<p>[3. Conduct qualitative data analysis] Indicative findings:</p> <ul style="list-style-type: none"> The CIO or CEO/Director in SMEs without an IT department is leading the decision-making process The decision-making process can be broken down into three phases (1) building perception about the cloud, (2) contextualizing the cloud, (3) exposing the cloud proposition 	<p>The results of the qualitative strand inform the interpretation of the results of the quantitative strand (interpret the significance of personnel innovativeness vs the insignificance of managerial innovativeness; analyze the relevance of business area for cloud adoption decisions)</p>	<p>[III. Conduct quantitative data analysis] Survey 2: $R^2 = 0.532$ Findings:</p> <ul style="list-style-type: none"> Remote access, cost-reduction, personnel innovativeness (i.e., the innovativeness of the leading decision maker) is significant ($p < 0.05$) Security concerns and managerial innovativeness is not significant
<p>Interim Meta-inferences</p> <p>[Survey 2: Interpretation of the results] Personnel innovativeness might trigger the initiation of the process and inspire the leading decision maker to retrieve information about the potential adoption from several sources.</p> <ul style="list-style-type: none"> The leading role of the CIO and the limited involvement of other top management executives might also explain why it is personnel innovativeness and not managerial innovativeness that is significant. Cloud adoption literature considers the decision to adopt cloud services as a horizontal organization-wide decision. However, we show that cloud adoption decisions are rather business-area specific, and thus cloud adoption factors are different when the business area in which the cloud service will be introduced is specified. 		

The following table (Table C5) summarizes the interim meta-inferences associated with the different cross-fertilizations. This table can be used to consolidate how the research conclusions were incrementally built.

Table C5. Resulting Interim Meta-Inferences along the Cross-Fertilizations

CF #	Interim meta-inferences
1	<p>[Survey 1: hypotheses and research model]:</p> <p>Key constructs:</p> <ul style="list-style-type: none"> cost reduction; security concerns; remote access <p>Hypotheses:</p> <p>H1: Perceived cost reduction positively influences intention to adopt cloud services H2: Perceived remote access positively influences intention to adopt cloud services H3: Security concerns negatively influence intention to adopt cloud services</p> <p>Target audience: cloud users</p>
2	<p>[Survey 1: Interpretation of results]</p> <ul style="list-style-type: none"> Security concerns might be more relevant for the technical people involved in decision-making Remote access: reflects the need of employees to easily connect to the organization’s premises even beyond working hours Results may differ if respondents are not actual users of the service
3	<p>[Semi-structured interviews, re-analyze current data]</p> <ul style="list-style-type: none"> Business area is indeed relevant in the cloud adoption decision-making process Remote access is found to be significant, which is explained by the fact that it often triggers the initiation of the process Cost reduction and security concerns also found to be significant and became relevant later in the process
4	<p>[Survey 2: hypotheses and research model]</p> <ul style="list-style-type: none"> Additional constructs: organizational innovativeness (managerial innovativeness and personnel innovativeness) Respondents (cloud decision-makers) invited to select the business area on which they report results (context) Additional hypotheses: H4: Personnel innovativeness positively influences intention to adopt the cloud in a specific business area H5: Managerial innovativeness positively influences intention to adopt the cloud in a specific business area <p>Target audience: cloud decision-makers</p>

5	<p>[Semi-structured interviews, re-analyze current data thinking about unexpected and inconsistent results]</p> <ul style="list-style-type: none">• Managerial innovativeness may be more relevant in the last phase of the decision-making process, whereas personnel (including CIO) innovativeness matters throughout the decision-making process.• CIO innovativeness, in particular, is critical during the early phases of the process, as it may determine whether a cloud solution is to be considered or not• Security concerns are reduced as decision-makers discuss options with peers and local/trusted vendors in Phase 2 of the decision-making process
6	<p>[Survey 2: Interpretation of the results]</p> <ul style="list-style-type: none">• Personnel innovativeness might trigger the initiation of the process and inspire the leading decision-maker to retrieve information about the potential adoption from several sources• The leading role of the CIO and the limited involvement of other top management executives might also explain why it is personnel innovativeness and not managerial innovativeness that is significant• Cloud adoption literature considers the decision to adopt cloud services as a horizontal organization-wide decision. However, we show that cloud adoption decisions are rather business-area specific, and thus cloud adoption factors are different when the business area in which the cloud service will be introduced is specified

Appendix D: Validation of Interdependent Mixed Methods Research by Both Junior Researchers and Experienced Colleagues

To evaluate our proposal for interdependent mixed methods research beyond our research experience, we sought feedback from a small number of both experienced and junior colleagues. We approached potential interviewees through our network, achieving some gender and regional diversity (see Table D1 for details). We invited respondents to discuss their research experience; experienced respondents talked about their choices in the use of mixed methods (e.g., design, execution, analysis) and challenges (how their paper evolved, revisions or deviations from the research design, challenges in reporting on mixed methods research results) whereas junior respondents presented their research plans (content and methodology). We then presented the DNA helix analogy and the flow diagram (Section 3.3) seeking feedback on our proposed interdependent research design from both groups.

Table D1. Overview of Interview Participants

	Experienced researchers	Junior researchers
Number of interviews	3 (online, 1 hour long; recorded & transcribed) (ia1-ia3)	5 (online, 45 minutes -1 hour long; recorded & transcribed) (i1-i5)
Demographics of respondents	female: 2; male: 2	female: 3; male: 2
	AIS regions: R1: 1; R2: 2, 1 R3: 1	AIS regions: R1: 2; R2: 3
	2 lead authors, 2 second authors of a paper using concurrent mixed methods. The 3 papers discussed were published in the three 4* ABS ranked IS journals	4 second-year doctoral students; 1 junior post-doc researcher

The senior respondents confirmed our perceived gap in the literature, which is lacking both in guidance and in published exemplars of mixed methods research that fully disclose the iterations and recurrence that naturally occur. They had to make choices about which part of their story they present, at times in response to reviewer requests. Certainly, not all details “fit” in a journal paper. Nonetheless, it appears that presently, the dynamic and incremental evolution that takes place during the research process goes mostly undocumented and therefore unnoticed. In mixed methods, in particular, research is dynamic, iterative, and messy, as confirmed by our interviewees. Researchers may have to leave out important insights on how the knowledge was incrementally built and, instead of the actual story, they may have to report only what they believe fits an acceptable presentation format. We argue that this possibly results in important stories, pertinent to the phenomenon under study, remaining untold. This also often creates misconceptions for readers of mixed methods research, especially junior researchers, who cannot easily decrypt how the research in a published paper was actually conducted.

The feedback of the experienced researchers (see Table D2 for indicative quotes) acknowledged the DNA helix as a helpful analogy for concurrent mixed methods research and found the concepts of cross-fertilization and interim meta-inferences relevant, resonating with their own experience. We appreciate that this feedback was influenced by our presentation and explanations. Our colleagues did not test it in practice. However, they encouraged and supported our proposals as a template relevant to their research work and one that is closer to how mixed methods research happens in practice. They found the idea of cross-fertilization particularly important, as well as the ongoing iterations that the diagram allows and enables. The challenge they identified had to do with balancing the complexity of the flow diagram against the value it adds in guiding interdependent research. They also noted that our diagram may still miss part of the complexity. For example: “What if you are not collecting the data in parallel?” (ia3). In response to these comments, we revisited the presentation of our approach and expanded our discussion of the flow diagram that now appears in Section 3.3. One respondent also challenged us to move away from defining mixed methods research strands as either qualitative or quantitative so as to encompass a broader set of paradigms that are inclusive of more recently available types of research that do not neatly fit in either strand, such as content-rich big data or AI-enabled data collection and analysis (ia1). This led us to extend our original discussion of the interdependent design and acknowledge that a research strand in contemporary IS research may deviate markedly from traditional qualitative or quantitative approaches.

Table D2. Feedback by Experienced Researchers

Feedback	Indicative evidence
Mixed methods research is dynamic, dialectical, and iterative	<p>“the research process was very much a moving back and forth between these two [research strands]” (ia2); “this is a kind of dynamic process for us” (ia3) and “that’s because of this abductive process, where you try different theories, you try different quantitative data, you try different interpretations of the qualitative data and then, over time, you get this sort of tighter and tighter integration between these diverse forms of data and the theory. And after a certain point, you just say like, well, all of this fits together pretty nicely!” (ia1).</p> <p>“... it’s messy, it’s dynamic. And that’s not a bad thing. I think that the messiness and dynamic aspect of it is what makes it rich” (ia3)</p> <p>“the reviewers came back and then we might think, okay, there’s another idea here, let’s get back to the quantitative data ... the qualitative analysis kind of led us to look at things in the quantitative data” (ia3).</p>
Data collection is ongoing in research	<p>“the data collection is continuous until very, very late in the research process” (ia1)</p> <p>“the review team suggested to use the new data to also enrich our already presented data” (ia1).</p>
A helpful metaphor	“DNA helix; I think that’s one metaphor that definitely could be used!” (ia1).
The concept of cross-fertilization is valuable	<p>“And I do like the fact that something like this forces you to do or forces the reader to think about the cross-fertilization and of how one [strand] can inform the other. That’s really great actually, because by doing this, you as a researcher, you don’t want to collect the data, and then think: Oh, hell, what am I going to do with this now? Like, you know what I do with this qualitative and quantitative data set, by doing this cross-fertilization of research insights at the start, it kind of forces you to think about well, this form of data collection will give me x data, this will give me y data, it is our hope that one to inform the other, when I have these later on, and then can draw my meta-inferences. That’s really cool” (ia3).</p>
Interim meta-inferences “make sense” and can help an honest write-up	“[drawing interim meta-inferences] makes a lot of sense. And I think researchers would appreciate [this] kind of guidelines and instructions on how to write-up these papers where they use the methods kind of [at the] same time, and how to write them, and then they have some format for that as well. I personally think it’s extremely important to write the things as they happen in practice” (ia2).
Printed work does not report the actual research process	“so it [the quantitative research] was almost like a way of validating or checking our hunches. Oh, I think ‘checking our hunches’ is a good way of putting it because this is what the quantitative data allowed us to do. And I don’t think we mentioned that in the paper” (ia3).
The complexity of the flow diagram is a challenge	<p>“The two parts of the helix ... you bring a lot of complexity...” (ia1).</p> <p>“But what if you are not collecting the data in parallel? So often, like I said, one person may collect the qualitative data in January, then the quantitative person in the quants may start in June. So, how does the pragmatics of research come into this?” (ia3).</p>

The responses of junior researchers were also overall very positive toward our proposed mixed methods design, recognizing its potential as a roadmap for navigating through the complexity of such research consciously and systematically and for accruing benefits from the insights provided. Due to their relative inexperience, junior researchers are those who rely most on methodological guidelines for planning and validating their research. Our junior respondents also appreciated the flexibility and transparency our approach offers as well as the support it provides for research write-up (see Table D3 for indicative quotes). Three junior researchers (i1, i2, i5) spontaneously pointed out that the recursion of the interdependent study occurs naturally and is comparable to agile system development or the lean approach followed by start-up companies. This is a similarity we had not realized, but, indeed, the cycles in our approach can be compared to sprints in agile methodology in the sense that they focus on conducting a smaller part of the research and delivering interim meta-inferences. The challenge for junior researchers lies in the difficulty of knowing when to stop thinking about possible cross-fertilizations and their impact. Indeed, this entails the exercise of professional judgment, which becomes easier with experience but, even so, is open to scrutiny in peer review.

Table D3. Feedback by Junior Researchers

Feedback	Indicative evidence
A useful “how-to” tool	the proposed approach can assist in “a by-design process” (i2), help with the question: “How do you systematically think about the methodology?” (i2) and “save time” (i4).
Assists in transparency and write-up	“this methodology seems like it provides a formalized representation that researchers can provide, an honest accounting of how the [research] question developed while the analysis developed, without having to either write two separate papers, or write one paper where you pretend that you had all these insights beforehand” (i3).
Similar to agile development	“The approach reminds me of agile methodologies. You are executing a sprint. You find some [interesting] insights in the first sprint, then in the second sprint, you begin using the inferences of the first one” (i2).
Recursion is natural and helpful	recursion might not be conscious (i2); it occurs more naturally in mixed methods research designs (i1, i2) and thus it can “help you refine the design” (i1).
Challenge: knowing when to stop	“for me, it would be very difficult to know when to cut off and say, okay, now, I have to stop thinking about it, and just get on with the experiment until the end” (i1).

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