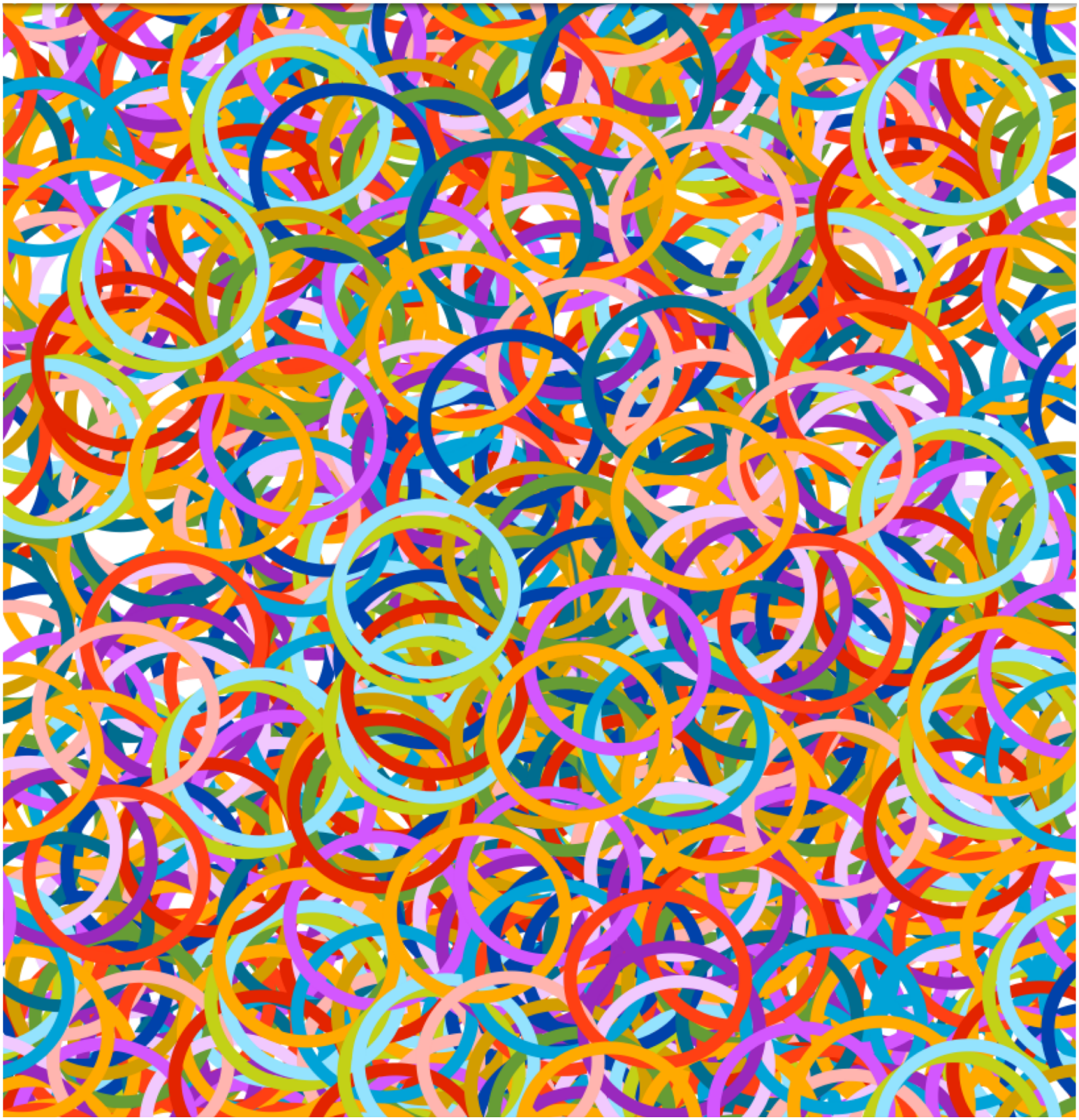
JIM
Journal of Innovation Management
The International Journal on Multidisciplinary Approaches on Innovation
Volume 7 Issue 3 | 2019 | open-jim.org



ISSN 2183-0606
FEUP Edições

Volume 7 - Issue 3

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ISSN 2183-0606
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Journal of Innovation Management
JIM 7, 3 (2019) 1-9
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0001

Towards the Science of Managing for Innovation: Interim Discussions on Innovation Research Methodologies

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In our previous editorial, we positioned our perspective and introduced the acronym "ROTRUS" to characterise the science of managing for innovation as – Real world, Observable, Testable, Replicable, Uncertain and Social. Specifically, we argued that methods that draw on point-in-time beliefs, perceptions and de-humanised data in a complex and evolving social setting of innovation management pose a challenge for replicability. We warned innovation researchers to avoid the pitfalls that might foster pseudoscience and generalised assumptions from information that is still in the proto-science stage. Drawing on longstanding understanding in psychology of the whole human, we discussed the need to explore methods that capture brain, mind and behaviour aspects in innovation management, spanning the analysis from individual to group and societal levels. In this editorial, we move the discussions forward by focusing on one plausible methodological approach to advance the science of managing for innovation – behavioural experiments. In the following sections, we explain our methodological stance or in other words our world view followed by a brief review of behavioural experiments and their relevance to innovation research. We conclude with a foreword on our final editorial in the series titled the science of managing for innovation.

Methodological stance

If we are to believe that actions are a result of implicit judgement of value and actions accentuate problems (Malachowski 2013), then there remains no validity in the distinction of theoretical and practical perspectives. Truth cannot be found merely through questions in theory, and any such

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separations of questions of truth are only questions for the defensible means of action (Newman and Benz 1998). Important to note that scholars have for decades reasoned for the 'plurality of paradigms' to progress the science of management, and in doing so, have called on researchers to embrace the 'fuzzy boundaries' (Cannella and Paetzold 1994, 332). We agree with these and other innovation researchers (see Adams et al. 2016; Ferraro, Etzion and Gehman 2015) and believe that individuals adopt a pragmatic perspective when managing for innovation. Resembling a real-time dynamic game with its many players, individuals in innovation management may experience situations and happenstance that does not follow strict sequence of events, rather decisions may emphasize reliance on patterns of interactions as the game unfolds (O'Donohue 2016).

Although largely understood in a broader management context, research at the intersection of innovation and knowledge management is yet to embrace a holistic and pragmatic agenda (O'Donohue 2016). Perhaps, there is a need for cross-disciplinary search when advancing the science of managing for innovation. For instance, Antons and Pillar (2015) argued that individual behavioural outcomes in open innovation are closely associated with displaced cognition, yet management scholars have long known that it is not the conflicting cognition rather it is how one resolves the cognitive discrepancy that guides behavioural responses (Hinojosa, Gardner, Walker, Cogliser, and Gullifor 2017). Based on these purviews, it might be tempting to assume that one's adaptive cognition is merely a representation of perceived behavior. Yet, Ajzen (2011) does not believe so, since application of his theory of planned behaviour has repeatedly proved that cognition is merely a formative indicator and it is ultimately one's intention that predicts behaviour (Ajzen, 2011; cf. Sniehotta, Presseau, and Araújo-Soares 2014; Kautonen, Gelderen, and Fink 2015). Indeed, Covey (1989) drew attention to the patterns of mental representations affecting cognition and attention to experiences, both from individualistic and collective perspective that shapes the humanistic purview of the world and the sense of humanly 'being'. Thus, we argue that actions enacted by individuals during the innovation process are nothing more than mental lessons which cannot be proved or disproved until acted upon and empirically observed with some objectivity. In this view, the mental representations that reflect hypothetical internal cognitive symbols of an external reality may be logically recognised through real world observations, but the final test of its accuracy requires objective evidence through hypotheses testing (Maddux and Donnett 2015). This calls for discounting of a priori dominant position to positivism or interpretivism paradigms, in turn requiring a pragmatic epistemology to find the best possible alternative and encourage diverse intellectual purviews through multi-disciplinary choice that powers the scientific and practice-oriented dialogue in the discourse.

Behavioural experiments as a plausible method

Weimann (2015) identified five research settings (Fig 1) - (1) neoclassical based on game theoretical models with highest probability of establishing causality, (2) traditional research capturing self-reported data collected using surveys or patent statistics with inherent endogeneity and selectivity issues, yet high-level of external validity and feasible application, (3) natural experiments embedded in the 'field' allowing for substantiation of causality within contextual parameters, but lacking applicability across contexts and domains, (4) randomised field experiment in which treatment conditions are recognised in real-life incidents, offering the 'gold standard' of expe-

rimentation with an optimal trade-off between causal inferences and external validity, and (5) laboratory experiments which provide the high-level causality and applicability, offering a pragmatic solution to expensive randomised field experiments and novel insights to phenomenon inaccessible by field innovation experiments. Weismann (2015) argued that each type of research setting has it strengths and limitations and ultimately, the selection should be guided by (1) research objective, (2) availability of data and (3) possibility of collecting data in through field experiments. Here, we briefly discuss the relevance of behavioural experiments, a pragmatic methodological solution between the positivism and interpretivism dichotomy.

Behavioural experiments are generally defined as a research methodology for controlled data generating from individual decision-makers who face real consequences to their responses, under random assignment, active participation and manipulation of context (real-world, role-playing). They have been widely applied in literature. The appendix to this editorial provides a short-list of studies which highlight how scholars across various disciplines have embraced behavioural experiments to unveil the idiosyncrasies at various decision-points within contextual boundaries. Be the subject of social co-creation, entpreneurial opportunity evaluation, exploration-exploitation or cheating and dishonesty, behavioural experiments have provided valuable insights into otherwise complex psychological processes. The approach provides a feasible solution to examine the cause and effect, a method that has also become a vital component of innovation research in recent years (Brüggemann and Bizer 2016; Chetty 2015; Sørensen, Mattsson and Sundbo 2010). Behavioural experiments draw on conventional experiments, yet embrace context dependencies, to test the effects on a dependent variable by manipulating the independent variables and controlling for all other conditions (Brüggemann and Bizer 2016; Gross and Krohn 2005). Individuals are randomly assigned to either only one treatment (between-subject design) or are exposed to multiple treatments (within-subject design) (see table 2, for a review see Charness, Gneezy, and Kuhn 2012). The manipulation process is typically implemented by assigning participating individuals randomly to groups that are treated differently, allowing for deeper understanding of the cognitive and social preferences to interactions and exchanges at isolated innovation decision-points (Willer and Harry 2007). This rationale supports the logic that in the pragmatic setting of innovation management where interactions are complex, disorderly and iterative (Fischer 2001), behavioural experiments provide a complementary and often alternative view to the roles of actors, the interrelatedness of variables and the interdependency of activities (Chetty 2015; Madrian 2014).

It is important to note that although experiments are mostly associated with quantitative methods, behavioural experiments may equally employ qualitative methods. Indeed, it may not be prudent to believe that experimental findings from a controlled laboratory setting would reveal effects same as those found in natural settings (Shaughnessy, Zechmeister and Zechmeister 2015). For instance, qualitative methods may become useful when contextual complexities pertaining to the variables under investigation cannot be conceptualized quantitatively or where it is not possible to undertake statistical methods. Action Research and Action Learning aimed at altering the practice through intervention and manipulation of causes are typical examples of such experiments (Baskerville and Wood-Harper 1996). Besides, a commonly implemented technique in studies involving human behavior have relied on conversational analysis (CA). Although criticized for redefining the basic constructs of mind and behaviour (Button, 1991; Kitzinger,

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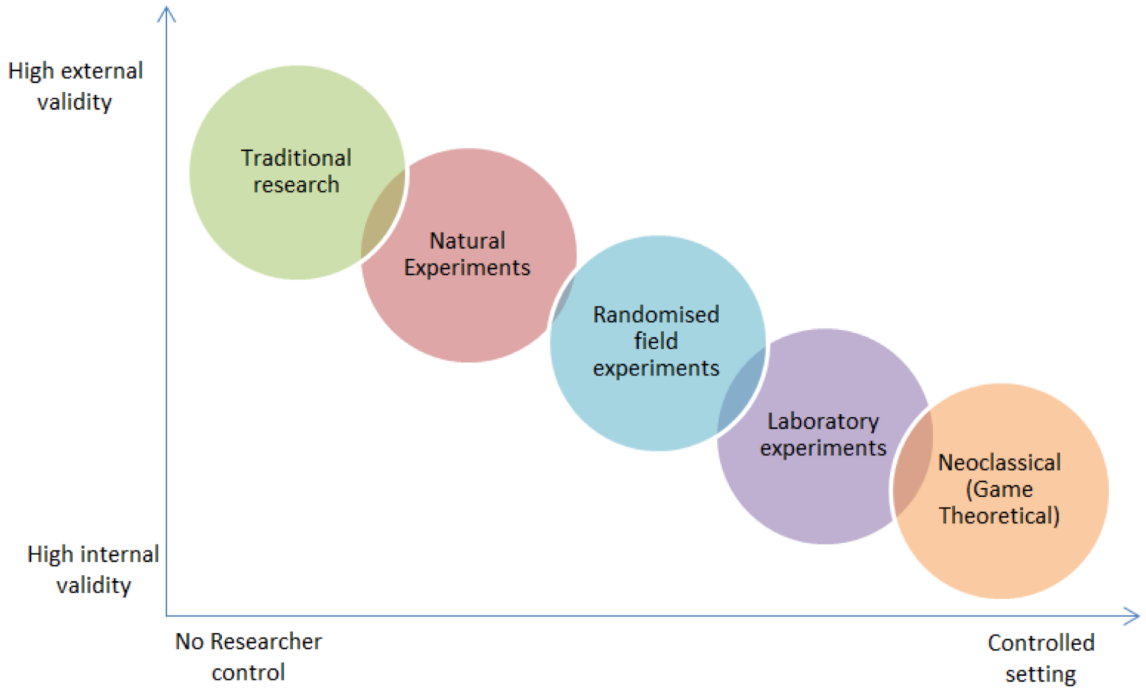

Fig. 1. Types of experiments, their features and delimitations (adapted from Sørensen, Mattsson and Sundbo (2010) and Weimann (2015))

2006), its value rests in reliance on naturalistic data (Ruiter and Albert 2017). Our premise for incorporating qualitative behavioural experiments in innovation research is based on the studies by Healey et al. (Healey, Howes, and Purver 2010; Healey, Purver, and Howes 2014) which refuted the highly cited laboratory findings of Branigan, Pickering and Cleland (2000), that people copy the verbal statements or words spoken by another during a dialogue more often than by chance. Qualitative behavioural experiments could enrich the quantitative experimental findings by providing an avenue to 'stay conceptually closer to actual social behavior "in the wild"' (Ruiter and Albert 2017, p.97).

If how to increase individual and group (human) creativity, collaboration productivity and innovativeness in innovation projects is a concern, then perhaps behavioural experiments present as a solution. Behavioural experiments provide means to explain how certain conditions affect specific actions and outcomes. These tests can be more generalizable than conventional experiments if a well-considered design is employed. Methodological benefits arise as outcomes of various innovation aspects, from ideation to marketing of products, can be analyzed by manipulating underlying social and cognitive variables of interest. A key feature of behavioural experiments is that they can accommodate complex variables and contexts and thus allow for integrated abstraction of socio-cognitive capabilities to inform wider innovation procedures in practice. Innovation research and practice is naturally based on experimentation, be influenced by reflection of past experiences, judgements in current social context or desired future and, thus our perspective has its merits.

ISSN 2183-0606
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In the next editorial, we will conclude the discussions on the science of managing for innovation with propositions for future research from a pragmatic stance. We will particularly highlight the role of behavioural experiments in advancing research at the intersection of human psychology and behaviour towards sustainable development. Meanwhile, we welcome your conceptual, theoretical, perspective and empirical contributions on topics that relate to innovation and its management.

Innovatively yours,

Anne-Laure Mention, João José Pinto Ferreira, Marko Torkkeli

The Editors

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Appendix: A short-list of studies incorporating behavioural experiment methods

ISSN 2183-0606
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Author	Sample	Subject area	Experiment design	Independent variables	Dependent variables	Behavioural instrument	Complementary technique	Key findings
Reypens and Levine (2018)	57 graduate students	Exploration-Exploitation decisions	Repeated measures, no deception	Search distances (close, far)	Pay-offs, % of time participant preferred a risky or ambiguous outcome	Wildcat Wells (Mason and Watts 2012); online card game	Think out Loud (Ericsson and Simon 1984)	Participants differ in how much they explore and when they choose to explore. Most who were comfortable under ambiguity were also comfortable under risk
Dai, Galeotti, and Villeval (2018)	279 public transport users	Cheating and dishonesty	Repeated measures, deception	individual characteristics, attitudes towards risk, usage of public transportation, norms, beliefs	outcome of the first die roll; decision to not buy a ticket for a given destination	Lottery bin (Eckel and Grossman 2008); die-under-cup (Fischbacher and Föllmi-Heusi 2013); Public transport game	Conventional lab experiment	Norm violators have lower intrinsic ethical values than others. Diversity of moral behaviour exists in both abstract (lab) and contextual (public transport game) settings. Dishonest behaviour persists in behavioural experiment predicts real-life behaviour.
Fan and Wang (2015)	106 undergraduate students	Social co-creation	Independent measures, deception	passive ignorance, active rejection, social acceptance	Self-defeating behaviour, intrinsic motivation	Vignettes		Only being passively ignored affected the intrinsic motivation to participate in social co-creation

Author	Sample	Subject area	Experiment design	Independent variables	Dependent variables	Behavioural instrument	Complementary technique	Key findings
Verleye (2015)	180 undergraduate students	Social co-creation	Independent measures, deception	Technologisation (high, low), connectivity (high, low)	Co-creation experience	Hands-on co-creation/design task		Expected co-creation benefits influence the level of role readiness, technologisation, and connectivity for the co-creation experience
Buchanan and Wilson (2014)	120 undergraduate students	Intellectual property rights	Repeated measures, limited disclosure	IP condition, no IP condition	Time spend creating IP protected products, total value of goods	Digitised trading game	Qualitative analysis of chat room exchange	IP protection is neither necessary nor enough for generating value from discovery of knowledge goods
Grichnik, Smeja, and Welpe (2010)	146 entrepreneurs	Entrepreneurial opportunity evaluation and exploitation	Independent measures, limited disclosure	Emotion (positive, negative)	Opportunity evaluation and opportunity exploitation	Vignettes (short case studies)	Expert judgement (mainly for real-world validation of case studies)	Positive emotion affects opportunity evaluation positively but exploitation negatively. Negative emotions affect both opportunity evaluation and exploitation negatively

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 7, 3 (2019) 10-14
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0002

Picturing Future Imaginaries for Innovations Towards Sustainability Transitions

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Letter from Academia

Abstract. Sustainability is about the world we need but are not quite sure how to garner consensus about what it should be. As it is yet to exist, we can always imagine what it could be and design networks for this transition. Such innovation networks fueled by imaginaries could offer countless opportunities for transition incentivized through applications like tokens, available through decentralized ledger technologies (DLTs).

Keywords. Sustainability; Network; Imaginaries; Transition; Innovation; Consensus; Tokens; DLTs.

Cite paper as: Narayan, R., (2019). Picturing Future Imaginaries for Innovations Towards Sustainability Transitions - Letter from Academia, *Journal of Innovation Management*, www.open-jim.org, 7(3), 10-14.

ISSN 2183-0606
http://www.open-jim.org

The Canadian historian Benoît Godin, in his extensive work[1] on innovation, notes that when the term first appeared in the thirteenth century legal texts for renewing contracts, it signified newness not creativity. According to Godin, the framing[2] was not particularly positive and it was through the word's association with invention related to science and technology during the Industrial Revolution, that it acquired a positive and prestigious implication. However, it was Joseph Schumpeter, the Austrian economist, who framed its meaning to reflect acts of intellectual creativity, thus infusing the ideas behind the word with imagination. Within Schumpeter's framing this form of creativity was not given any overt economic objective, rather, it was to illustrate the various ways in which inventions could be imagined to reflect unique changes in ways to run businesses (Fagerberg, 2007). For Schumpeter, the value was distributed, and not concentrated in one final objective. This perspective gains critical relevance in the information age.

It is within this framing that innovation acquires significance for transitions to sustainability, mainly because sustainability as a concept is abstract and is difficult to grasp within the current socioeconomic and technological paradigms (Adams et al., 2016; Seebode et al., 2012; Smith et al., 2010) and requires network building infused with imaginaries. Innovation, with a distributed understanding of value creation could open up possibilities for new combinations (Hart and Milstein, 1999) and network pictures inspired by imaginaries enable such combinations for transitions to sustainability. The possibilities for such combinations have always existed, but now with applications like tokens made available on decentralized ledger technologies (DLTs) we might have the tools to realize them.

Network pictures are strategic tools used by managers to make sense of the relationships within business networks (Abrahamsen et al., 2016; Hopkinson, 2015). Managers' decisions about how to interact, mobilize, and influence other actors through connected relationships is understood through their network picturing processes. Therefore, it is also useful as a strategic tool for fostering innovation networks (Möller, 2010). However, even as innovation garnered popularity and been credited for curing all sociotechnical issues, it has also been critiqued for not paying adequate attention to why such issues emerged in the first place (see Pfotenhauer and Jasanoff, 2017). As a result, there is a fundamental disconnect between the fruits of innovation and its effects. For example, using plastic for packaging due to the material's durable and indestructible properties is absurd if the packaging is meant to be discarded. Further, models of innovation where particular innovations are replicated without paying attention to the diverse contexts and their specific needs has fueled calls for linking innovation to sociotechnical imaginaries (Pfotenhauer and Jasanoff, 2017). In STS (science and technology studies) and policy research there is a push towards investigating images of the future related to innovations in specific contexts. By infusing imaginaries, innovation processes take into consideration what is imaginable and possible within distinct social, political, and historical contexts. In doing so, they offer a thread of continuity and stability by extending existing frames of reference from the past into the future, and mitigating the disruptive quality of innovation processes.

Combining imaginaries with network pictures expands the perspective of innovation to include a deeper societal engagement. One of the critical insights from Godin's account of the history

[1] http://www.csiic.ca/en/the-idea-of-innovation/
[2] http://www.csiic.ca/PDF/IntellectualNo6.pdf

ISSN 2183-0606
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of innovation is that the word has always been infused with the social and cultural climate of a particular time, and the history that this climate emerged out of. The interesting thing about innovation is not that it offers a singular way of solving problems; it is to understand the purpose; and the purpose is to aid in the process of creation, rather than arriving at a final solution. One can extrapolate from Godin's account that the term innovation enables the creation of ontological frameworks allowing people of a particular time grasp its meaning within their context, and in that innovation is, at its core, a creative practice. This practice requires an effective mechanism that would enable the weaving of organizational networks for sustainability.

Decentralized ledger technologies (DLTs) like the blockchain, have been repositioned as mechanisms for mobilizing far more than just payment reconciliation systems (Glaser, 2017; Kewell et al., 2017). The potential of such technologies in enabling a new system of value that clearly recognizes the coordination mechanism underlying our socioeconomic systems for increased social sharing remain underexplored. There are various layers of value creation that range from production of value, the record of value, to the actualization of value (see Pazaitis et al., 2017). In capturing and recording this information, DLTs make the various social interactions tangible and visible, and opens up opportunities for infinite combinations for innovations (Chen, 2018) that could enable transitions towards sustainability. These combinations could be incentivized by creating digital tokens to represent the value being exchanged and open up innovations across the layers of value.

Understanding innovation from this standpoint will require a different set of questions that explores what it means to be innovative in this time, and new ways of understanding the world, in order to offer us a different perspective. The questions, therefore, need to be framed within the general idea of how might one live. Framing questions within this idea is distinct from the past where the quest was to answer, how one should live and later to how one should act (May, 2003). The questions related to how one should live have been the preoccupation of ancient philosophers, where there is an assumption of hierarchy, a sort of transcendent order that we are required to adhere. This was followed by how should one act, where the individual takes precedence. The question of our time takes into cognizance the relevance of those past questions within their contexts to arrive at the question that asks – how might one live. This question acknowledges that our reality is chaos, and that is precisely why we are unable to coherently articulate or describe what it is we mean by sustainability. We do not have the tools to grasp the complexities that sustainability entails but we can use ontological systems devised of concepts that help us bring a semblance of order to that chaos. Innovation could be seen as the art of concept creation. To describe the role of innovation, it is important to understand what has been its role throughout history and to begin transitions, we should be willing to engage with imaginaries from the past and the present as well as the future for network building.

The goal of innovation is not to offer a final and coherent vision of sustainability but to offer us a window through which we can witness how people have interpreted innovation to solve the problems that are relevant to their culture and time. When we understand innovation from this perspective then it offers us a goldmine of useful ideas and new ways of realizing them.

ISSN 2183-0606
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ISSN 2183-0606
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Biographies

Rumy Narayan. Rumy studies transitions to sustainable energy systems. Her research interests fall within a framework of innovation possibilities that could potentially address pressing global challenges of our time, while stimulating societal and economic prosperity. This entails activating innovations across sectors, actors, and disciplines, while enabling experimentation, a complex process that needs appropriate tools for coordinating and managing diverse networks. Within this context, blockchain gains relevance for her research as it could be understood as an institutional and social technology for managing and coordinating disparate networks of actors.

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 7, 3 (2019) 15-40
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0003
SM: Mar/2018 AM: Apr/2019

Employee Innovation Process: An Integrative Model

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Abstract. Enormous research has focused on investigating innovation process in organisations but only a few are devoted to employee innovation process, thus limiting our understanding of how to organise, foster and successfully manage employee innovation in organisation. Drawing from the literature, this study extends the two-phase model of innovation process comprising creativity and innovation by proposing a three-phase employee innovation process model that integrates innovation adoption. Using stratified sampling technique and structured questionnaires, data were collected from 430 middle managers of four mobile telecommunication companies in Nigeria. Results of the regression and path analyses to test the hypotheses and model fit support a revised three-phase model of employee innovation process showing employee creativity has a direct causal effect on employee innovation and employee innovation adoption, and employee innovation as a direct causal effect on employee innovation adoption. Dispositional factors have stronger causal effects on employee creativity than contextual factors and contextual factors have stronger causal effects on employee innovation than dispositional factors. Both dispositional and contextual factors have comparably strong direct causal effects on employee innovation adoption, with the effects of dispositional factors slightly stronger. By providing evidence in support of a three-phase innovation process with innovation adoption as a concluding phase of the innovation process, this study has provided new, empirically based insights into the study of innovation process from employee unit of analysis. Implications for theory and practice are discussed.

Keywords. Dispositional and Contextual Factors; Employee Innovation Process; Integrative Model.

Cite paper as: Odetunde, O., (2019). Employee Innovation Process: An Integrative Model, *Journal of Innovation Management*, www.open-jim.org, 7(3), 15-40.

ISSN 2183-0606
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1 Introduction

Continuous innovation and adoption of innovative business model have been recognised as vital to both competitive advantage and long-term success of organisations. It is also recognised that innovation is one of the three top challenges facing organisations in today's business world. Without innovation, organisations fail to create the conditions needed for sustainable growth (Rao, 2016). The foundation of many of the innovations in organisations are the employees who invent, implement and adopt new technologies and business ideas in their individual work roles (Korzilius, Bücker and Beerlage, 2017).

The importance of innovation to organisational performance has attracted enormous research to be focused on innovation process and the antecedent factors in organization. Research has generally established innovation as a two-phase process of creativity (idea generation) and innovation (idea implementation) (e.g., Anderson *et al.*, 2004; Brennam and Dooley, 2005; Shalley and Gilson, 2004) with different factor implication. However, despite the recognition that adoption of innovation by individuals and organisations is a critical element of the innovation process leading to improved production process and operational efficiency, improved quality of products and services, organisational transformation and sustainable innovation, the implied linkage of innovation adoption to the process of innovation in literature has not been investigated. Isolating adoption from the innovation process has therefore made the process differentiation incomplete and the implications of this for theory and innovation management in organisations are enormous.

Besides creativity and innovation, adopting innovation is a critical element of the innovation process. Integrating adoption should therefore provide a clearer differentiation of the innovation process (Rank *et al.*, 2004) and better understanding of how employee innovation can be organised, fostered and successfully managed in organisations. Echoing the opinion of Jain (2010), better understanding of how organisations evolve in meeting the challenges of change and fulfilling the expectations of internal and external stakeholders requires a more sophisticated understanding of their innovation process. Consequently, building upon the extant literature which considers innovation as a two-phase process of creativity and innovation, this study conceptualises, tests and clarifies a three-phase model that integrates innovation adoption as the concluding phase of the innovation process and distinguishes among the antecedent factors of the different phases.

2 Literature, Hypotheses and Model Specification

2.1 Employee Innovation

Plessis (2007) views innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services. Walker (2006) defines innovation as a process through which new ideas, objects, and practices are created, developed or reinvented and which are new and novel to the unit of adoption. According to Baregheh *et al.*, (2009), innovation in organizational term is the process by which organizations transform ideas into new and improved products,

service or processes, in order to advance, compete and differentiate themselves successfully in the market.

Employee innovation implies that employees contribute actively to the innovation process in organisation. They engage in activities to generate and transform creative ideas into innovative outcomes for organisations. Employees engage in innovation when they intentionally create, introduce and apply new ideas, processes, products or services within their work role, group, or organization (De Jong and Den Hartog, 2010; Yuan and Woodman, 2010; Abstein and Spieth, 2014).

Employee innovation is a critical element in organisational innovation process as the innovation capability of organisations derives from their employees' innovation capabilities. Buttressing the importance of employees to the organisational innovation outcomes, Patterson *et al.* (2009) opine that the innovative potential of an organisation resides in its employees who build, promote and breathe life into the innovative culture of organisation. Chen and Sawhney (2010) also stressed that human resources in organisation are the single most important ingredient in the organisation innovation success formula.

Employees can help their organisations to develop incremental improvements in features of existing process and products and services to maintain or increase market shares or to develop radically different novel ones to create new markets (Axtell *et al.*, 2000). Mild changes to technology, product process, administrative procedure, etc without complete or total replacement constitutes incremental innovation. Radical innovation tends to replace existing ideas, products, services, or processes, create new business model, etc. A typical example of radical innovation is the introduction of iPhone by Apple in 2007 which converted mobile phone to smartphone, converging the traditional cell-phone, Internet connectivity, and personal computing in a single device. This innovation created new needs and new market, setting new rules, redefining and revolutionising telecommunication. Incremental innovation is relatively easier and may be within the capability of many employees. Radical innovation is rather more complex, somewhat rare and within the capability of only few employees in strategic positions in organization. Employees' capabilities for both incremental and radical innovations help their organisations to grow and be successful in the world markets.

2.2 Two-Phase Employee Innovation Process: Creativity and Innovation

Innovation as a process denotes a chain of inter-connected activities involved in bringing forth and turning new ideas and possibilities into reality (Bessant and Tidd, 2007). Two phases of creativity and innovation have traditionally been conceptualised to comprise the innovation process. However, the two phases have been confused and used interchangeably in literature (Paulus, 2000), thus necessitating the need for a clearer process differentiation and set the boundaries and clarify the activities that constitute each (e.g. Rank *et al.*, 2004).

Clarifying the process, many authors have shown that the two processes differ and individually refer to distinct activities. Creativity refers to the generation of novel (i.e., original, unexpected) and useful ideas, products or problem solutions. Innovation however refers to the first introduction and successful implementation of the novel ideas and bringing of the new ideas to fruition. For example, Yuan and Woodman (2010) define innovation as a complex behaviour consisting of activities pertaining to both the generation of new ideas and their implementation. Parzefall

et al. (2008) and De Jong and Den Hartog (2010) view innovative behaviour as consisting of two major stages of idea initiation/generation and idea implementation. Mulgan and Albury (2003) view successful innovation as the creation and implementation of new processes, products, services and methods of delivery which result in entirely new or significant improvements in outcomes.

Employee innovation process can therefore be regarded as the sequence of activities employees engage in to generate and transform creative ideas into concrete and successful organizational outcomes. Creativity occurring at the front-end of the process, is a prerequisite and necessary starting point - but an insufficient condition – for innovation to occur (Dewulf, 2013; Yidong and Xinxin, 2013; Abstein and Spieth, 2014; Anderson *et al.*, 2014). Amabile (2004) further states that no innovation is possible without the creative processes that mark the beginning stage of the process. Therefore, without creative ideas to feed the innovation pipeline, so they may be promoted and developed, innovation is an engine without fuel (McLean, 2005).

2.3 Integrating Innovation Adoption

While innovation may be generated and implemented by employees within an organisation, innovation may also be generated outside of the organization (Zhou and Shalley, 2010). According to Anderson *et al.* (2004), innovation also includes ideas that have been adopted and adapted from other organizations but that are new to the unit of adoption. Adoption occurs when employees accept and decide to make full use of innovations generated from outside their organisation as the best course of action available (Rogers, 2003). The value and the success of innovation manifests in its ultimate adoption (Agarwal and Prasad, 1999). As noted by Rogers, innovation is successful only if it is accepted and integrated into the organisation and the target adopters demonstrate commitment to using it over time. Adoption therefore is the sourcing and using of innovation developed outside the unit of adoption. As most innovations result from "borrowing" rather than "invention" (Cohen and Levinthal, 1990; Garner and Ternouth, 2011), employee adoption of innovation and new knowledge from outside sources is critical to organisations' innovativeness and competitiveness.

Successful adoption of innovation is a function of personal innovativeness of adopter which refers to the innate tendency to produce and adopt innovation (Frambach and Schillewaert, 2002). The adoption component is determined by the employees' absorptive capacity; the ability of adopters to recognise potential value in outside innovations and new knowledge and their degree of receptiveness and willingness to convert and apply them to their use (Cohen and Levinthal, 1990). The speed and success of adoption are also determined by absorptive capacity. Based on absorptive capacity and speed of adoption, Rogers (2003) identified five adopter categories. The *innovators* and *early adopters* are the most successful adopters with high propensity to adopt and adapt innovation to their need. The *early majority* and *late majority* are sceptical of innovation and wait till the majority is using the innovation before adopting. This makes them less successful adopters as they often lose out on the advantages of early adoption. *Laggards* are particularly suspicious of and accept innovation only when it is indispensable. Innovators and early adopters who are better skilled in evaluating innovations more easily and are quick at recognising values in innovations and can help their organisation take advantage of first and early adoption of innovation are most suited for modern organisations as employees.

The above exposition suggests that employee innovation transcends simply developing and implementing innovation. Employee innovation includes the capacity to adopt, adapt and exploit existing innovation. Any study of employee innovation process should therefore include adoption of innovation. Supporting this position, Vincent *et al.* (2002) and Parzefall *et al.* (2008) asserted that employee innovation spans initial idea generation to new process development, and the adoption of new processes or structures in the organisation. Other authors also implied innovation process as comprising three phases with adoption as an integral phase. Rogers (2003) conceives innovation process as beginning with the invention of an idea (creativity), through its development, production and testing into a concrete device or programme (innovation) and culminating in its diffusion to and adoption by users. Hansen and Birkinshaw (2007) represent innovation value chain as involving idea generation, idea conversion and development, and diffusion to others of the developed concepts. Kamal (2006) and Baregheh *et al.* (2009) also portray innovation as comprisingof idea (invention) of something new; development (production) of something new, and commercialization (diffusion/adoption) of something new. Employee innovation can therefore be considered as the process by which employee generate, implement and adopt innovation in their work role.

Failure of previous studies to integrate adoption as a phase of employee innovation and clearly discern the processes involved and their antecedents have limited our understanding of the innovation process and how to manage the employee innovation process in organisation. For this reason, calls have been made for integrative frameworks to broaden the understanding of the innovation process (e.g., Anderson *et al.*, 2014). Accordingly, the two-phase innovation process of creativity (idea generation) and innovation (idea implementation) established in literature is considered inadequate to explain the employee innovation process and this study conceives an integrative three-phase employee innovation process of creativity (new idea generation) occurring at the front-end of the process with innovation (first introduction and implementation of the new idea) as a mid-process and adoption (acceptance and use of innovation and the new idea) concluding the process. To test this assumption, it is hypothesised that:

> *Hypothesis 1*: Employee creativity has a direct causal effect on employee innovation and employee innovation has a direct causal effect on employee innovation adoption.

2.4 Dispositional and Contextual Factors Facilitating Employee Innovation Process

Employee innovation as a complex phenomenon has been established to have multiple antecedent factors including the dispositional and contextual factors of the individuals and organisations (Anderson *et al.*, 2014; Baer, 2012). The initiative toward innovation in organisation originates from the employees and this is rooted in their dispositional characteristics which include personality factors, abilities, orientation, motivational factors etc. The initiative is however facilitated by contextual factors encompassing types of job, nature of work team and task, and organisation-related factors like work environment that provide the boundaries for employee innovative behaviour (Stock, 2015; Fay *et al.*, 2014; Naranjo-Valencia *et al.*, 2017). According to Åmo and Kolvereid (2005), even with the right individual characteristics, how employees perceive the organisational context influences their innovative behaviour, thus implying that individual

and organisational factors act interactively to influence employee innovative work behaviours (Hannele and Parzefall, 2007).

With the conceptual differences in the innovation process established in literature, the different phases may not necessarily be influenced by the same factors. While it has been established that dispositional factors correlate more strongly with creativity (idea generation) phase and contextual factors more strongly with innovation (idea implementation) (Damanpour, 2017; Rank *et al.*, 2004), both dispositional and contextual factors have been implied to relate equally to adoption. As noted by Moore (2002), while management may wish to encourage and facilitate individual adoption of innovation by providing the necessary organisational support and enabling work context, eventual acceptance and decision to adopt innovation depends on the individual adopters and some individuals may accept and adopt innovation more readily than others. Conversely, while an individual may be willing to adopt innovation, the prevailing organisational context may not encourage such decision. The context provides the opportunities for individuals with the right disposition to adopt innovation. This implies that innovation adoption depends not only on the individual adopter but, also on the work context.

Thus, innovation adoption may fail if either the dispositional or the contextual factors are missing. Both dispositional and contextual factors are therefore equally important in innovation adoption. In particular, studies have correlated dispositional factors like achievement orientation, proactivity, role breadth self-efficacy and individual competitiveness (e.g., Gautam *et al.*, 2008; Kim *et al.*, 2010; Odetunde, 2012) and contextual factors like participation in decision making, work autonomy, organisational communication and management support (e.g., Damanpour and Schneider, 2006; Sá and Abrunhosa, 2007; Damanpour and Aravind, 2012; Crossan and Apaydin, 2010; Odetunde, 2012) with adoption of innovation. Therefore, it is hypothesised that:

> *Hypothesis 2(a):* Dispositional factors have stronger direct causal effects on employee creativity than contextual factors.
>
> *Hypothesis 2(b)*: Contextual factors have stronger direct causal effects on employee innovation than dispositional factors.
>
> *Hypothesis 2(c)*: Both dispositional and contextual factors have comparably strong direct causal effects on employee innovation adoption.

2.5 Model Specification

Bean (2002) advocates for a model to manage innovation process in organisation and believes a model allows the situation to be seen more clearly and assists in the understanding of how employee innovation is generated, supported and sustained. It is therefore important within the framework being considered to conceptualise a model that integrates the adoption phase into the employee innovation process and clarify variable implication for the different facets for a clearer understanding and better management of the employee innovation process. Consequently, from the literature reviewed above and the derived hypotheses, a model of employee innovation process is conceptualised as depicted in Figure 1.

The model assumes direct causal relationships between employee creativity $_{(3)}$ and employee innovation $_{(4)}$ (P_{43}) and employee innovation $_{(4)}$ and employee adoption of innovation $_{(5)}$ (P_{54})

(Hypothesis 1), dispositional factors $_{(1)}$ and employee creativity $_{(3)}$ (P_{31}) (Hypothesis 2a), contextual factors $_{(2)}$ and employee innovation $_{(4)}$ (P_{42}) (Hypothesis 2b) and dispositional $_{(1)}$ and employee adoption of innovation $_{(5)}$ (P_{51}), and contextual factors $_{(2)}$ and employee adoption of innovation $_{(5)}$ (P_{52}) (Hypothesis 2c). The model also assumes no direct causal relationships between employee creativity and employee adoption of innovation, dispositional factors and employee innovation, and contextual factors and employee creativity.

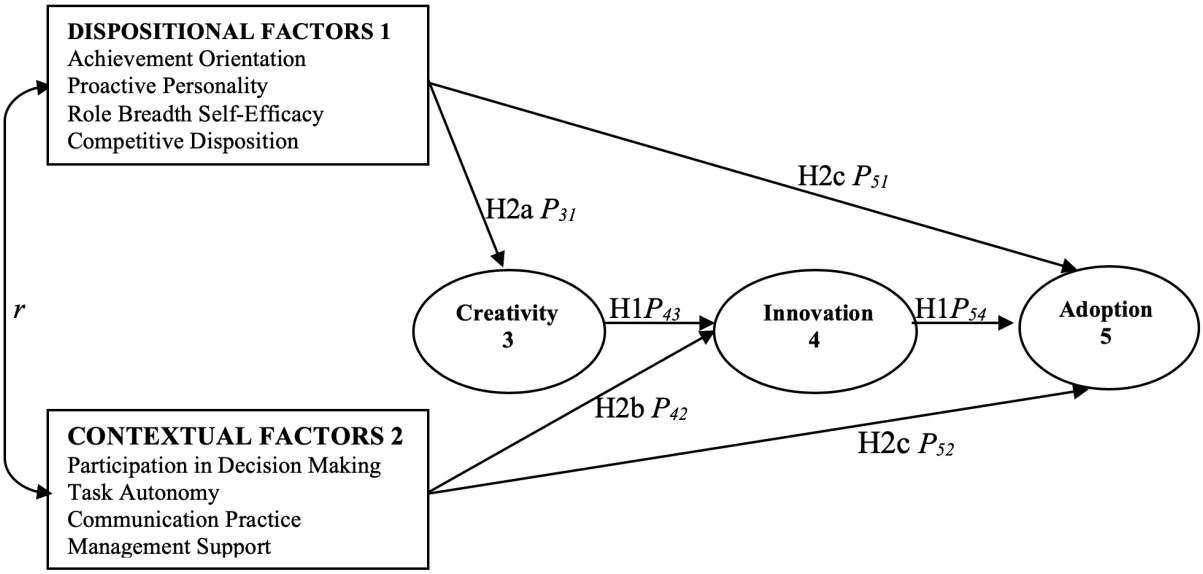

Fig. 1. Integrated model of employee innovation process showing the hypothesised phases and their antecedent factors.

3 Methods

3.1 Research Setting

The setting for this research is the head offices and 20 regional offices and outlets of four mobile telecommunication companies in Nigeria. As a high technology, innovation intensive and highly competitive industry where employee innovation is a required capability for organisational growth and survival, mobile telecommunication industry offers appropriate setting for the study. Studies assert that innovation in such high technology industry does not so much rely on R&D-based knowledge, but on the internal sources for knowledge from employees and managers, especially the middle managers who implement, facilitate, synthesise and drive the innovation process as part of their core responsibilities (Birken et al., 2012; Engle et al., 2017). The setting for this research is the head offices and 20 regional offices and outlets of four mobile telecommunication companies in Nigeria. As a high technology, innovation intensive and highly competitive industry where employee innovation is a required capability for organisational growth and survival, mobile telecommunication industry offers appropriate setting for the study. Studies assert that innovation in such high technology industry does not so much rely on R&D-based knowledge,

but on the internal sources for knowledge from employees and managers, especially the middle managers who implement, facilitate, synthesise and drive the innovation process as part of their core responsibilities (Birken *et al.*, 2012; Engle *et al.*, 2017).

3.2 Participants and Data Collection Procedure

Participants were middle managers of four mobile telecommunication companies in Nigeria. Stratified random technique was adopted to ensure that data were collected from all the departments in their head offices and 26 regional offices and outlets. From a total of 660 middle managers initially sampled from across all departments of the telecommunication companies, 442 (67%) participated in the study with usable data from 430 (65%). Two hundred and seventy-eight (64.7%) were males and 152 (35.3%) females. Their ages ranged from 24 to 52 years (x = 33.2). Three hundred and forty-seven (80.7%) have first university degree and eighty-three (19.3%) have post-graduate degree/diploma. Their job experience in their respective companies ranged from 2 to above 10 years (x = 4.8).

The departments across the four companies are diverse in nature and activities. To facilitate data collection, the departments were clustered into 5 based on similarity of their functions and activities. A proportion of 50% of total number of middle managers in each department was selected to be able to generate enough data. Their distribution across the 5 departments is as follows: Administration - 40 (9.3%), Commercial - 156 (36.3%), Technical/Maintenance - 151 (35.1%), Operations - 73 (17%) and Finance - 10 (2.3%). Participants filled self-administered structured questionnaires during their lunch break. Data collection lasted 16 weeks with two to four visits made to each participant.

3.3 Measures

Employee Creativity, Innovation and Innovation Adoption: Employee creativity and innovation were measured by Borill *et al.*'s (1998) measures of idea and suggestion making and implementation as modified by Odetunde (2012). The two scales, each with 9 items, tap information on the extent to which employees propose improved changes to various aspects of their work and the suggested changes were implemented. Six items on each of the two original scales were modified and 3 new items derived from the literature of creativity and innovation added to tap information on other work domains not covered in the original scales. Sample items on the creativity scale include: *In the last one year or so, to what extent have you*: 1) suggested new ways of performing your job or jobs of others, 2) provided new solutions to problems identified in your job or jobs of others, 3) suggested new methods of improving operational efficiency of your work unit. Sample items on the innovation scale include: *In the last one year or so, to what extent have you implemented*: 1) your suggestions on new ways of performing your job or jobs of others, 2) your new solutions to problems identified in your job or jobs of others, 3) your suggestions on new methods of improving operational efficiency of your work unit.

The employee innovation adoption scale also consists of 9 items derived from literature of innovation adoption (for example, Roger's theories of adoption, 2003; Lenox *et al.*, 2000). Items

on the scale were structured to explore the extent to which employees adopt or have adopted innovation in the same job domains covered by the creativity and innovation scales. Sample items include: *In the last one year or so, to what extent have you adopted from others*: 1) new ways of performing your job, 2) new solutions to problems identified in your job, 3) new methods of improving operational efficiency of your work unit.

Dispositional and Contextual Factors: The dispositional scales comprise of validated scales of achievement orientation (10 items), proactive personality (Bateman and Crant, 1993) (6 items), role breadth self-efficacy (Parker, 1998) (10 items) and competitive disposition (Odetunde, 2012) (9 items). The contextual scales comprise of validated scales of participation in decision-making (Parker *et al.*, 1997) (5 items), task autonomy (Jackson *et al.*, 1993) (5 items), communication practices (Parker, 1998) (9 items) and management support (Parker *et al*, 1998) (10 items).

Response to the employee creativity, innovation and innovation adoption scales is a 5-point Likert format ranging from 1 (to no extent) to 5 (to a very great extent) and a 5-point Likert format ranging from 1 (Strongly disagree) to 5 (Strongly agree) for the dispositional and contextual scales. Test of reliability with item-total correlation coefficients ranged from 0.59 to 0.76 for creativity, 0.63 to 0.81 for innovation and 0.65 to 0.81 for innovation adoption scales, and 0.53 to 0.77 and 0.53 to 0.80 respectively for dispositional and contextual scales. Howitt and Cramer (1997) suggested item-total correlation coefficient of 0.40 as sufficient to establish internal consistency of a scale. Cronbach alphas for creativity, innovation and innovation adoption range from 0.74 to 0.93; dispositional factors from 0.86 to 0.92 and contextual factors from 0.85 to 0.94.

4 Results

Means, standard deviations, and zero-order correlations of all the variables are shown in Table 1. Employee creativity positively relates to employee innovation ($r = 0.69$, $p<.001$) and employee innovation adoption ($r =0.62$, $p<.001$). Employee innovation also positively relates to employee innovation adoption ($r =0.71$, $p<.001$). As expected, dispositional factors show stronger positive relationships with employee creativity ($r =0.53$, $p<.001$) than contextual factors ($r =0.42$, $p<.001$) and contextual factors show stronger positive relationships with employee innovation ($r =0.54$, $p<.001$) than dispositional factors ($r =0.46$, $p<.001$). Contextual factors show stronger relationship with employee innovation adoption ($r =0.53$, $p<.001$) than dispositional factors ($r =0.49$, $p<.001$).

4.1 Hypotheses Testing

Hypotheses were tested with hierarchical regression analyses. Sequence of the employee innovation process and their antecedent factors as established in literature informed the entry of variables into the regression equations. Demographic variables were entered en-block in step 1 of the regression equations, followed in steps 2 and 3 by the appropriate dispositional and contextual factors to determine their respective causal effects on each phase of the innovation process. Employee creativity was used as a precursor of employee innovation and employee in-

Table 1. Descriptive statistics, correlations among all variables

	Variable	Means	SD	1	2	3	4	5
1	Employee Creativity	31.30	6.47	1.00				
2	Employee Innovation	30.67	7.16	0.69**	1.00			
3	Employee Innovation Adoption	31.63	7.05	0.62**	0.71**	1.00		
4	Dispositional Factors	136.58	20.49	0.53**	0.46**	0.49**	1.00	
5	Contextual Factors	117.36	20.38	0.42**	0.54**	0.53**	0.50**	1.00

$^{**}p<.01$, N= 430

novation as a precursor of employee innovation adoption in the analysis. Similarly, dispositional and contextual factors were used as determinants of the employee innovation process.

Results of the analyses of casual effects of employee creativity on employee innovation and employee innovation on employee innovation adoption are shown in Table 2. Employee creativity accounted for 56% of the variance in employee innovation (R^2= *0.56, p<.001*), resulting in a change of 43% of the variance in employee innovation (ΔR^2= *.43, p<.001*) and employee innovation adoption accounted for 65% of the variance in employee innovation (R^2= *.65, p<.001*), resulting in additional change of 9% of the variance in employee innovation (ΔR^2= *.09, p<.001*). Employee innovation also accounted for 55% of the variance in employee innovation adoption (R^2= *.55, p<.001*) with 42% change of the variance (ΔR^2= *.42, p<.001*) and employee creativity accounted for a variance of 58% (R^2= *.58, p<.001*) resulting in a change of 3% of the variance (ΔR^2= *.03, p<.001*). Assessment of their unique causal effects using their beta weights revealed that employee creativity accounted for more unique variance in employee innovation (β=*.43, p<.001*) than employee innovation adoption (β=*.41, p<.001*). Employee innovation also accounted for more unique variance in employee innovation adoption (β = *.50, p<.001*) than employee creativity (β = *.42, p<.001*). Therefore, Hypothesis 1 was confirmed that employee creativity has direct causal effect on employee innovation and employee innovation has direct causal effect on employee innovation adoption.

Results of the analyses of causal effects of dispositional and contextual factors on employee creativity, employee innovation and employee innovation adoption in Table 3 show that dispositional factors produced a variance of 35% in employee creativity (R^2=*0.35, p< .001*) resulting in a change of 27% of the variance (ΔR^2=*0.27, p< .001*) and contextual factors produced a variance of 38% (R^2=*0.38, p< .001*) resulting in a change of 3% (ΔR^2=*0.03, p< .001*). Thus, both dispositional and contextual factors significantly produced variance in employee creativity thereby having causal effect on employee creativity. Assessment of their unique causal effect using their beta weights (β) shows that the dispositional factors have stronger causal effect on employee creativity (β=*0.45, p<.001*) than the contextual factors (β=*0.21, p<.001*).

Table 2. Hierarchical Regression Analyses of the Causal Effects of Employee Creativity on Employee Innovation and Employee Innovation Adoption.

Dependent Variables	Independent Variables	F	R^2	$Adj\text{-}R^2$	ΔR^2	β
Employee Innovation	Step 1: Demographic Variables	8.37**	0.12**	0.11	0.12**	-
	Step 2: Employee Creativity	409.73**	0.56**	0.55	0.43**	0.43**
	Step 3: Employee Innovation Adoption	112.87**	0.65**	0.64	0.09**	0.41**
Employee Innovation Adoption	Step 1: Demographic Variables	8.78**	0.13**	0.11	0.13**	-
	Step 2: Employee Innovation	391.97**	0.55**	0.54	0.42**	0.50**
	Step 3: Employee Creativity	32.15**	0.58**	0.57	0.03**	0.26**

$^{**}p < .001$

Table 3. Hierarchical Regression Analyses of Causal Effects of Dispositional and Contextual Factors on Employee Creativity, Innovation and Innovation Adoption.

Dependent Variables	Independent Variables	F	R^2	$Adj\text{-}R^2$	ΔR^2	β
Employee Creativity	Step 1: Demographic Variable	5.08**	0.08*	0.06	0.08*	-
	Step 2: Dispositional Factors	176.97**	0.35**	0.34	0.27**	0.45**
	Step 3: Contextual Factors	18.63**	0.38**	0.37	0.03*	0.21**
Employee Innovation	Step 1: Demographic Variables	8.37**	0.12**	0.11	0.12**	-
	Step 2: Contextual Factors	130.15**	0.33**	0.32	0.21**	0.34**
	Step 3: Dispositional Factors	44.97**	0.39**	0.38	0.07*	0.30**
Employee Innovation Adoption	Step 1: Demographic Variables	8.78**	0.13**	0.11	0.13**	-
	Step 2: Dispositional Factors	133.13**	0.34**	0.32	0.21**	0.34**
	Step 3: Contextual Factors	39.51**	0.39**	0.38	0.06*	0.30**

$^{**}p < .001$, $^{*}p < .01$

Contextual factors produced a variance of 33% ($R^2=0.33,\ p< .001$) resulting in a change of 21% of the variance in employee innovation ($\Delta R^2=0.21,\ p< .001$) and dispositional factors accounted for a variance of 39% ($R^2=0.39,\ p< .001$) resulting in a change of 7% of the variance ($\Delta R^2=0.07,\ p< .001$). Thus, both contextual and dispositional factors significantly produced variance in employee innovation thereby having causal effect on employee innovation. Their beta weights (β) however shows that the contextual factors have stronger causal effect on employee innovation ($\beta=0.34,\ p<.001$) than the dispositional factors ($\beta=0.30,\ p<.001$).

Dispositional factors produced 34% variance ($R^2=0.34,\ p< .001$) with in a change of 21% of the variance in employee innovation adoption ($\Delta R^2=0.21,\ p< .001$) and contextual factors accounted for 39% variance ($R^2=0.39,\ p< .001$) with a change of 6% of the variance in employee innovation adoption ($\Delta R^2=0.06,\ p< .001$). Both dispositional and contextual factors, therefore, produced

significant variance in employee innovation adoption thereby having causal effects on employee innovation adoption. However, their beta weights (β) reveals that the dispositional factors have unique stronger causal effect on employee innovation adoption *(β=0.34 p<.001)* than the contextual factors *(β=0.30, p<.001)*.

4.2 Assessment of Model Fit

The hypothesised model was tested with path analysis to determine the causal effects of the exogenous variables (dispositional and contextual factors) on the endogenous variables (employee creativity, employee innovation and employee innovation adoption). The correlation matrix was first determined as shown in Table 1. Then, multiple regression analysis was conducted to obtain the coefficients of each of the direct paths from the exogenous to the endogenous variables in the model. The beta weights obtained from these analyses were then used as path coefficients (see Table 4). Tolerance statistics obtained range from 0.58 to 0.94 to indicate that multi-collinearity cannot be assumed among the study variables (Pedhasur, 1982; Mertler and Vannatta, 2005). Fig. 2 depicts the path diagram with the path coefficients.

Table 4: Path Coefficients of the Included Paths for the Exogenous and Endogenous Factors in the Hypothesised Model in Figure 2.

Paths	Variables	β	Tolerance
P_{31}	Employee Creativity $_{(3)}$ vs. Dispositional Factors $_{(1)}$	0.54**	0.94
P_{42}	Employee Innovation $_{(4)}$ vs. Contextual Factors $_{(2)}$	0.24**	0.71
P_{43}	Employee Innovation $_{(4)}$ vs. Employee Creativity $_{(3)}$	0.59**	0.76
NN P_{51}	Employee Innovation Adoption $_{(5)}$ vs. Dispositional Factors $_{(1)}$	0.17**	0.65
P_{52}	Employee Innovation Adoption $_{(5)}$ vs. Contextual Factors $_{(2)}$	0.11**	0.58
P_{54}	Employee Innovation Adoption $_{(5)}$ vs. Employee Innovation $_{(4)}$	0.56**	0.61

$^{**}p < .001$

Model fit was assessed by obtaining reproduced correlations through decomposition of the path coefficients into direct and indirect paths as reflected by the arrows in the model. Direct causal effects (D) consist of straight arrows that flow in only one direction from the exogenous to the endogenous variables. Indirect causal effects (I) consist of arrows going in two or more directions. Spurious effects (S) are path components resulting from paths that have reversal causal direction at some point, indicating that the relationship is caused by a common third factor (Tate, 1992). This implies that portions of the effects are not due to either direct or indirect causal effects. In the hypothesised model in Fig. 2, the paths between the exogenous variables which include a curved arrow are spurious effects. Unanalysed effects (U) are causal effects in the endogenous variables due to the correlations among the exogenous variables. This is indicated by a double-headed arrow connecting them. The reproduced correlations were obtained by summing all the decomposed correlations and comparing them with the empirical correlations and then evaluating them against the difference criterion of .05 using chi-square goodness-of-fit tests. Chi-square goodness-of-fit tests show that there is no significant difference between reproduced and the empirical correlations (χ^2 = *0.00* to *0.09, ns*), indicating model fit. Table

5 shows the procedure of path decomposition and calculation of reproduced correlations for the Exogenous and Endogenous Factors in the Hypothesized Model in Figure 2.

Table 5. Path Decompositions and Calculation of Reproduced Correlations for the Endogenous and Exogenous Factors in the Hypothesized Model in Figure 2.

Reproduced Correlation	Path Decomposition and Calculations of Reproduced Correlations
r_{12}	**0.50**
r_{13}	P_{31} = **0.54** (D)
r_{14}	$(P_{31}P_{43})$ + $(r_{12}P_{42})$ (I) (U) (0.54×0.59) + (0.50×0.24) = 0.32+0.12 = **0.44**
r_{15}	P_{51} + $(P_{31}P_{43}\ P_{54})$ + $(r_{12}P_{42}P_{54})$ + $(r_{12}P_{52})$ (D) (I) (U) (U) $0.17+ (0.54\times0.59\times0.56)$ + $(0.50\times0.24\times0.59)$ + (0.50×0.11) $0.17+0.18 +0.07+0.05$ = **0.47**
r_{23}	$(r_{12}P_{31})$ (U) (0.50×0.54) = **0.27**
r_{24}	P_{42} + $(r_{12}P_{31}P_{43})$ (D) (U) 0.24 + $(0.50\times0.54\times0.59)$ $0.24+0.16$ = **0.40**
r_{25}	P_{52} + $(P_{42}P_{54})$ + $(r_{12}P_{31}P_{43}\ P_{54})$ + $(r_{12}P_{51})$ (D) (I) (U) (U) $0.11+ (0.24\times0.56)$ + $(0.50\times0.54\times0.59\times0.56)+(0.50\times0.17)$ $0.11+0.13+0.09+0.08$ = **0.41**
r_{34}	P_{43} + $(P_{31}r_{12}P_{42})$ (D) (S) 0.59 + $(0.54\times0.50\times0.24)$ $0.59+0.06$ = **0.65**
r_{35}	$(P_{43}P_{54})$ + $(P_{31}r_{12}P_{42}P_{54})$ + $(P_{31}r_{12}P_{52})$ + $(P_{31}P_{51})$ (I) (S) (S) (S) (0.59×0.56) + $(0.54\times0.50\times0.24\times0.56)$ + $(0.54\times0.50\times0.11)$ + (0.54×0.17) $0.33+0.04+0.03+0.09$ = **0.49**

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r_{45}	$P_{54} + (P_{43}P_{31}r_{12}P_{42}P_{54}) + (P_{43}P_{31}r_{12}P_{52}) + (P_{43}P_{31}P_{51})$ $(D) \quad (S) \quad (S) \quad (S)$ $0.56 + (0.59\times0.54\times0.50\times0.24\times0.56) + (0.59\times0.54\times0.50\times0.11) +$ $(0.59\times0.54\times0.17)$ $0.56+0.02+0.02+0.05 =$ **0.65**

Key: D = Direct Effects, I = Indirect Effects, S = Spurious Effects and U = Unanalysed Effects

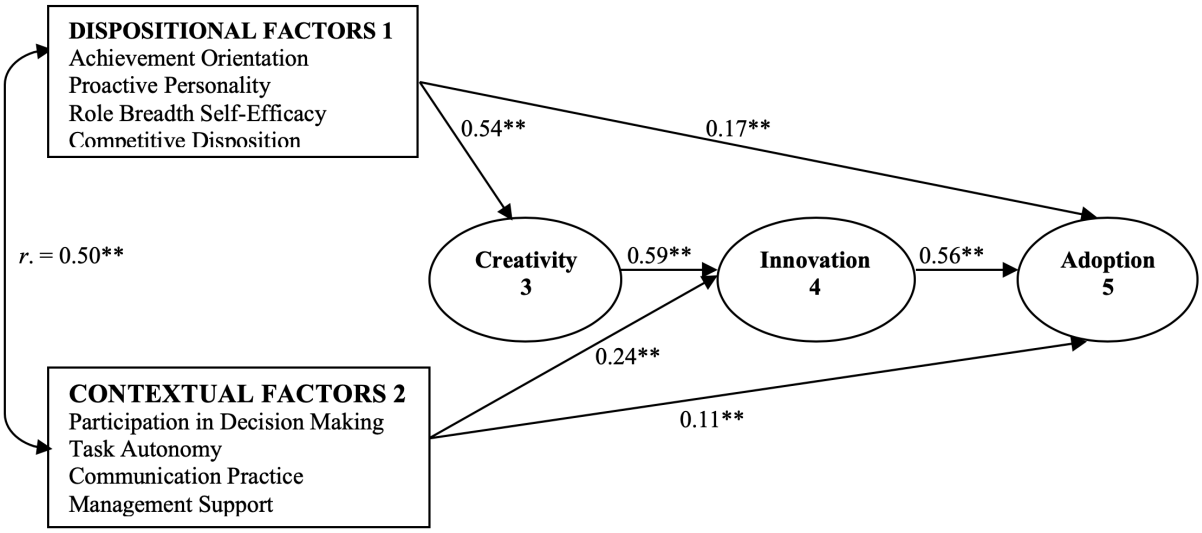

Fig. 2. Path Diagram of the Hypothesized Model of Employee Innovation Process Showing Path Coefficients.

A revised model was assessed for a better fit by retaining all paths and including all missing paths in the model. Table 6 shows the beta weights of the supplementary regression analyses conducted on the missing paths. Results suggest that missing paths from contextual factors to creativity ($\beta = 0.21$, $p<.001$) and creativity to adoption ($\beta = 0.20$, $p<.001$) be included in the model. The revised path diagram with path coefficients is shown in Fig. 3.

Model fit was reassessed following the same procedure as above. Calculations of the re-decomposed correlations can be seen in Table 7. Chi-Square Goodness-of-Fit tests show that the reproduced and empirical correlations are consistent ($\chi^2 = 0.00$ to 0.06, ns) indicating better model fit. Thus, the revised model fits the empirical data better than the hypothesised model.

Table 6: Path Coefficients of the Included and Missing Paths for the Exogenous and Endogenous Factors in the Hypothesised Model in Figure 2.

Paths	Variables	β	Tolerance
P_{32}	Employee Creativity $_{(3)}$ vs. Contextual Factors $_{(2)}$	0.21**	0.65
P_{31}	Employee Creativity $_{(3)}$ vs. Dispositional Factors $_{(1)}$	0.45**	0.72
P_{41}	Employee Innovation $_{(4)}$ vs. Dispositional Factors $_{(1)}$	0.05	0.58
P_{42}	Employee Innovation $_{(4)}$ vs. Contextual Factors $_{(2)}$	0.22**	0.63

Paths	Variables	β	Tolerance
P_{43}	Employee Innovation $_{(4)}$ vs. Employee Creativity $_{(3)}$	0.57**	0.62
P_{51}	Employee Innovation Adoption $_{(5)}$ vs. Dispositional Factors $_{(1)}$	0.11**	0.58
P_{52}	Employee Innovation Adoption $_{(5)}$ vs. Contextual Factors $_{(2)}$	0.10**	0.58
P_{53}	Employee Innovation Adoption $_{(5)}$ vs. Employee Creativity $_{(3)}$	0.20**	0.41
P_{54}	Employee Innovation Adoption $_{(5)}$ vs. Employee Innovation $_{(4)}$	0.44**	0.40

**p< .001

Table 7. Path Decompositions and Calculation of Reproduced Correlations for the Exogenous and Endogenous Factors in the Revised Model in Figure 3.

Reproduced Correlation	Path Decomposition and Calculations of Reproduced Correlations
r_{12}	**0.50**
r_{13}	$P_{31} + (r_{12}P_{32})$ (D) (U) $0.45+(0.50 \times 0.21)$ $0.45+0.10 =$ **0.55**
r_{14}	$(P_{31}P_{43}) + (r_{12}P_{32}P_{43}) + (r_{12}P_{42})$ (I) (U) (U) $(0.45\times0.59) + (0.50\times0.21\times0.59) + (0.50\times0.24)$ $0.26+0.06+0.12 =$ **0.44**
r_{15}	$P_{51} + (P_{31}P_{43}\ P_{54}) + (r_{12}P_{32}P_{43}P_{54}) + (r_{12}P_{42}P_{54}) + (r_{12}P_{52})$ (D) (I) (S) (U) (U) $0.11+ (0.45\times0.59\times0.44) + (0.50\times0.21\times0.59\times0.44) + (0.50\times0.24\times0.44) + (0.50\times0.10)$ $0.11+0.12 +0.03+0.05+0.05 =$ **0.36**
r_{23}	$P_{32} + (r_{12}P_{31}) = 0.21+ (0.50 \times 0.45)$ (D) (U) $0.21+0.22 =$ **0.43**
r_{24}	$P_{42} + (P_{32}P_{43}) + (r_{12}P_{31}P_{43})$ (D) (I) (U) $0.24 + (0.21\times0.59) + (0.50\times0.45\times0.59) = 0.24+0.12+0.13 =$ **0.49**
r_{25}	$P_{52} + (P_{42}P_{54}) + (P_{32}P_{43}P_{54}) + (r_{12}P_{31}P_{43}\ P_{54}) + (r_{12}P_{51})$ (D) (I) (I) (S) (U) $0.10+ (0.24\times0.44) + (0.21\times0.59\times0.44) + (0.50\times0.45\times0.59\times0.44) + (0.50\times0.11)$ $0.10+0.11+0.05+0.06+0.06 =$ **0.38**
r_{34}	$P_{43} + (P_{31}r_{12}P_{42}) + (P_{31}r_{12}P_{32}P_{43})$ (D) (U) (S) $0.59 + (0.45\times0.50\times0.24) + (0.45\times0.50\times0.21\times0.59)$ $0.59+0.05+0.03 =$ **0.67**

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r_{35}	$P_{53}+ (P_{43}P_{54}) + (P_{31}P_{51}) + (P_{31}r_{12}P_{32}P_{43}P_{54}) + (P_{31}r_{12}P_{42}P_{54}) + (P_{31}r_{12}P_{52})$ *(D) (I) (S) (S) (S) (U)* $0.20+(0.59\times0.44)+(0.45\times0.11)+(0.45\times0.50\times0.21\times0.59\times0.44)+(0.45\times0.50\times0.24\times0.44)+(0.45\times0.50\times0.10)$ $0.20+0.26 +0.05+0.01+0.03+0.02 = \mathbf{0.57}$
r_{45}	$P_{54} + (P_{43}P_{31}P_{51}) + (P_{43}P_{31}r_{12}P_{32}P_{43}P_{54}) + (P_{43}P_{31}r_{12}P_{42}P_{54}) + (P_{43}P_{31}r_{12}P_{52})$ *(D) (I) (S) (S) (S)* $0.44+(0.59\times0.45\times0.11)+(0.59\times0.45\times0.50\times0.21\times0.59\times0.44)+(0.59\times0.45\times0.50\times0.24\times0.44)+(0.59\times0.45\times0.50\times0.10)$ $0.44+0.03+0.01+0.02+0.01 = \mathbf{0.51}$

Key: D = Direct Effects, I = Indirect Effects, S = Spurious Effects and U = Unanalysed Effects

Summary of comparison of the reproduced and the empirical correlations for both the hypothesised and the revised models are presented in Table 8.

Table 8. Summary of the Empirical and Reproduced Correlations for the Endogenous and Exogenous Factors in the Hypothesized and the Revised Models.

	Dispositional Factors	Contextual Factors	Creativity	Innovation	Adoption
	1	2	3	4	5
Empirical Correlations					
1	1.00				
2	0.50	1.00			
3	0.53	0.42	1.00		
4	0.46	0.54	0.69	1.00	
5	0.49	0.53	0.62	0.71	1.00
Reproduced Correlations (Hypothesized Model)					
1	1.00				
2	0.50	1.00			
3	0.54	0.27	1.00		
4	0.44	0.40	0.65	1.00	
	1	2	3	4	5
Reproduced Correlations (Revised Model)					
1	1.00				
2	0.50	1.00			
3	0.55	0.43	1.00		
4	0.44	0.49	0.67	1.00	
5	0.36	0.38	0.57	0.51	1.00

Direct and indirect causal effects of the exogenous variables on the endogenous variables were calculated to obtain the causal effects on the revised model (Mertler and Vannatta, 2005). The summary of the direct, indirect and total causal effects of the exogenous variables on the endogenous variables in the revised model are presented in Table 9. In addition, R^2 is noted for each exogenous variable in the revised model within the summary Table.

The outcomes of primary interest were employee creativity, employee innovation and employee innovation adoption. The major determinant of employee creativity with the largest total causal effect are the dispositional factors (*0.45*). Other determinants of employee creativity are contextual factors (*0.21*). Approximately 43% ($R^2 = 0.43$) of the variance in employee creativity was explained by this model.

Table 9: Summary of the Causal Effects of the Exogenous on the Endogenous Factors in the Revised Model in Figure 3.

		Causal Effects		
DVs	IVs	Direct	Indirect	Total
Employee Creativity	Dispositional Factors	0.45**	-	0.45†
($R^2 = 0.43$)	Contextual Factors	0.21**	-	0.21†
Employee Innovation	Employee Creativity	0.59**	-	0.59†
($R^2 = 0.62$)	Dispositional Factors	-	0.26	0.26†
	Contextual Factors	0.24**	0.12	0.46†
Employee Innovation Adoption	Employee Creativity	0.20**	0.26	0.46†
($R^2 = 0.62$)	Employee Innovation	0.44**	-	0.44†
	Dispositional Factors	0.11**	0.12	0.23†
	Contextual Factors	0.10**	0.16	0.26†

***Direct effect is significant at .001 Level*
†Total effect may be incomplete due to unanalysed components.

The major determinant of employee innovation with the largest total causal relationship is employee creativity (*0.60*). Other determinants of employee innovation are the contextual factors (*0.46*) and the dispositional factors (*0.26*). Approximately 62% ($R^2 = 0.62$) of the variance in employee innovation is explained by this model. The major determinant of employee innovation adoption with the largest total causal effect is employee creativity (*0.46*). Employee innovation (*0.44*), contextual factors (*0.26*) and dispositional factors (*0.23*) are other determinants of employee innovation adoption. This model explains 62% of the variance in employee innovation adoption.

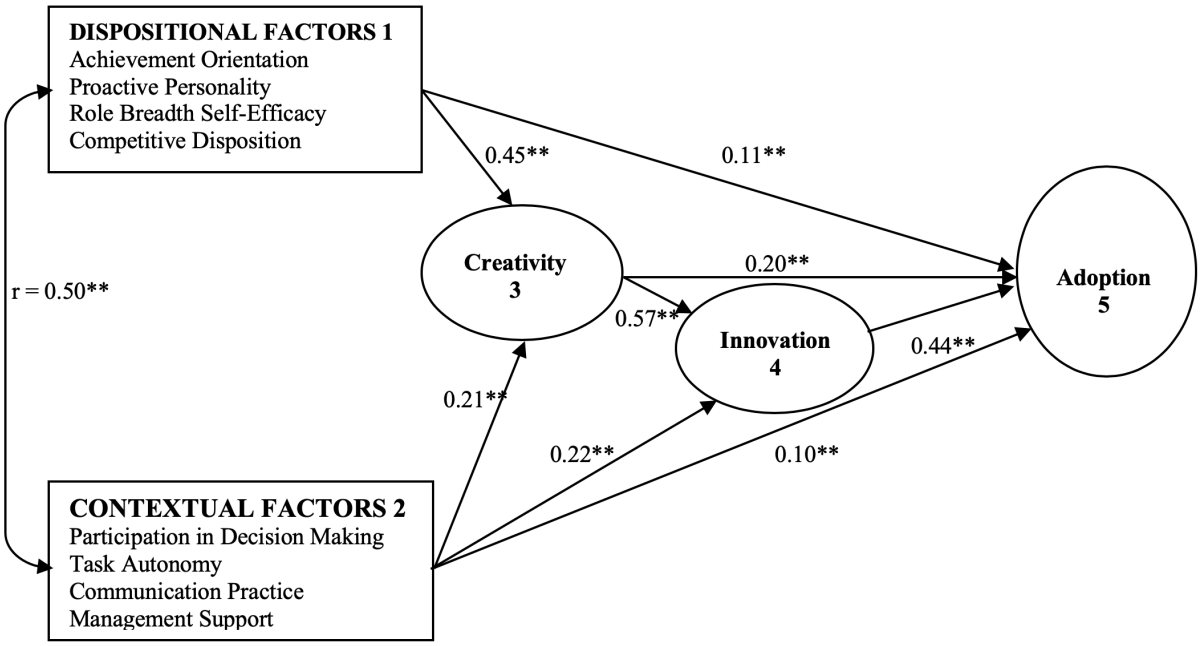

Fig. 3. Revised model of employee innovation process showing the phases and their antecedent factors

5 Discussion and Conclusion

Guided by the gap in literature, this study conceptualized a three-phase employee innovation process to facilitate our understanding of how to manage the process in organisations. The study has achieved its objectives by providing empirical support for its theoretical conceptualizations. First, beyond the two-phase process of creativity and innovation established in literature, this study found support for the hypothesised three-phase model of employee creativity, employee innovation and employee innovation adoption. In progressive sequence, employee creativity has direct causal effect on employee innovation which also has direct causal effect on employee innovation adoption. Employee creativity also has direct causal effect on employee innovation adoption. Thus, the study has been able to extend the innovation process by integrating adoption. Thus, the three-phase employee innovation process comprises: 1) employee creativity (idea generation phase) that occurs at the front end of the process, 2) employee innovation (idea implementation phase) occurring in the middle of the process and 3) employee innovation adoption (innovation acceptance and use phase) that concludes the process.

Second, the study has also confirmed antecedent factor implication for the three phases. Results show that dispositional factors have stronger causal effect on employee creativity than contextual factors and contextual factors have stronger causal effect on employee innovation than dispositional factors and both dispositional and contextual factors have strong causal effect on employee innovation adoption. Evidence however suggests that dispositional factors more strongly impact employee innovation adoption than contextual factors. This result has thus confirmed the position in literature that creativity is a process oriented in the individual, innovation is a social process oriented in a social context and innovation adoption is oriented both in the individual and context, though it is more of an individual decision process (West, 2002).

Finally, two significant unexpected shifts occurred in assessing the model fit. One, creativity showed direct causal effect on innovation adoption. This implies that creativity does not only have indirect causal effect

on innovation adoption through innovation, it also has direct causal effect on innovation adoption. This suggests that inventions can be adopted and used outside the unit of invention before they are introduced by the inventor(s). This is possible through spill-over of information about invention to other interest parties like competitors, which can occur through movements of employees or through common input suppliers and customers (Baptista, 2000).Finally, two significant unexpected shifts occurred in assessing the model fit. One, creativity showed direct causal effect on innovation adoption. This implies that creativity does not only have indirect causal effect on innovation adoption through innovation, it also has direct causal effect on innovation adoption. This suggests that inventions can be adopted and used outside the unit of invention before they are introduced by the inventor(s). This is possible through spill-over of information about invention to other interest parties like competitors, which can occur through movements of employees or through common input suppliers and customers (Baptista, 2000).

Two, contextual factors showed direct causal effects on employee creativity, which suggests that contextual factors not only have direct impact on employee innovation, they also directly impact employee creativity. This supports the position of authors in literature that the organisational context has impact on individual creativity efforts and that creativity cannot be understood outside a larger system of social networks, problem domain and fields of activity (e.g., Amabile, 2012; Gomes et al., 2016).Two, contextual factors showed direct causal effects on employee creativity, which suggests that contextual factors not only have direct impact on employee innovation, they also directly impact employee creativity. This supports the position of authors in literature that the organisational context has impact on individual creativity efforts and that creativity cannot be understood outside a larger system of social networks, problem domain and fields of activity (e.g., Amabile, 2012; Gomes *et al.*, 2016).

5.1 Implications of the Study

There are theoretical and practical implications of the study. Theoretically, the study has extended the two-phase innovation process in literature and confirmed employee innovation process as a three distinct, sequentially linked phases of creativity (idea generation) at the front-end, innovation (idea implementation) in the middle linking idea generation stage with innovation adoption at the concluding end. The study also shows the factor implication of the different phases. Since numerous factors differentially relate to the different facets, failure to make such distinction in previous studies limited our understanding of the employee innovation process. A point to note is that employee innovation process extends beyond the capacity to generate and implement new ideas, but innovative employees are characterised by receptiveness, willingness and absorptive capacity to adopt and exploit the values in the innovation of others. It is hoped that this study will stimulate more theory building discuss to further enhance better understanding of the employee innovation process.

Practically, the study has implication for employee innovation management. To foster employee innovation and organisational innovation capabilities, the study suggests that both dispositional and contextual factors are important. Specifically, attention should be focused more importantly on the employee dispositional factors to facilitate employee creativity/idea generation, though instituting the appropriate organisational context will help to accentuate the employee creativity process. Similarly, contextual factors are more important to facilitate innovation/idea implementation and having employees with the appropriate dispositional factors will enhance innovation/idea implementation success. Having employees with the requisite dispositional characteristics with the appropriate organisational context will facilitate the employee innovation adoption.

The study also has implication for training and development and workplace design to increase employee innovation. It is widely believed that innovation-relevant skills can be trained and learned by anyone (Bharadwaj and Menon, 2000; Shalley and Gilson, 2004) and as Tynjälä (2003) reasoned, the innovative skills, abilities and personality required in the contemporary organisations which include those exposed

in this study can be trained. Although these attributes can be tested during selection process, they are more context-specific and can only be developed in the real work setting. Therefore, in addition to hiring individuals with the right dispositional characteristics, findings of this study can be used to design training and development packages to sustain and enhance employee innovation capabilities. Apart from training employee innovation skills, employee work context can be designed with the contextual factors in this study to further stimulate and enhance their innovation capabilities.

5.2 Limitations and Directions for Future Studies

The study has some limitations which suggest directions for future studies. First, the study focused on middle managers of mobile telecommunications industry. This implies limited external validity. As such the findings of the study cannot be generalized beyond the context of study. Consequently, the study can be replicated in other service and manufacturing contexts like finance, communication and advertising, small and medium scale enterprises (SMEs) and the public sector. Studies should also consider other employees, especially top managers in organisations. Studies have highlighted the strategic position of top managers in organisational innovation process. Top managers affect innovation because they modulate the process of scanning the environment and formulating policy to respond to environmental change; they control resources and influence major decisions, especially strategic decisions on innovation. They are a potent force for or against innovation and are largely responsible for the cultural values that prevail in support of innovation within the organization (Damanpour and Schneider, 2006; Elenkov *et al.*, 2005).

Second, measures of innovation process used are not concrete and specifically defined because the middle managers used in this study perform varied and diverse tasks across their different work settings which made it difficult to explore specific work innovations common to all. The feasible thing to do was to rely on their self-report of innovation at work. Self-report scales are however fraught with response bias. It is possible for the managers to inflate their innovative performances than they truly are. Such responses compromise the internal validity of a study. Thus, it is important to state that the findings of this study apply only to employee self-reported innovative performance but may not generalize to more objective measures of innovative performance. Future studies should therefore consider using managers with similar work roles in order to adopt more detailed and comprehensive research method like longitudinal approach using combined observation and interviews in addition to structured questionnaires. This will allow for more objective assessments of actual employee innovative performance and provide a richer understanding of the employee innovation process.

Future studies should also consider exploring further innovation process differentiations and their antecedent factor implications. Studies have highlighted some sub-processes within each phase of the innovation process. For example, sub-stages of creativity phase are said to include, needs and opportunity identification, idea generation, preparation, incubation, illumination and verification, and idea promotion (West, 2002; Howell and Boies, 2004). Sub-stages in innovation phase include innovation development, first introduction and implementation. Adoption sub-stages include pre-adoption, adoption and post-adoption stages (Jasperson *et al.*, 2005; Damanpour and Schneider, 2006). Antecedent dispositional and contextual factors in this study may impact differently on these sub-processes. Studies have also emphasized the importance of job characteristics and team compositions with complementing skills and knowledge, education and work history to enhance employee innovative behaviour (Bogers *et al.*, 2018; Zhou and Velamuri, 2018). There is need for future studies to integrate and explore how these factors impact the different phases of the employee innovation process.

Several researchers have hinted that innovation process is cyclical (e.g. Björk *et al.*, 2010; Škerlavaj *et al.*, 2014). The implication of this is that innovation adoption can be a precursor of creativity leading to generation of fresh ideas that could lead to modification of and improvement in existing innovation.

This suggests that while innovation adoption marks the end of one cycle of innovation, it could also be a good feedback loop for further idea generation which marks the beginning of another innovation cycle. Therefore, it will be a good idea for future research to explore adoption as a possible feeder of the innovation pipeline.

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ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 7, 3 (2019) 41-68
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0004
SM: Set/2018 AM: Abr/2019

Boosting service innovation: the role of consultancies

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Abstract. This paper seeks to make a particular contribution in what are the roles of consultancies as key innovation intermediaries in service industry. Intermediation literature mostly focuses on the analyzing the contribution of intermediaries in manufacturing context and in technological innovation. More recently, the importance of intermediaries in service context and non-technological innovation has been discussed. In line with the emergent literature, the research aims to shed more light on the perceived importance of consultancies as innovation intermediaries in service industry, from the point of view of service clients. Four in-depth case studies of service companies were developed, resulting on detailed descriptions of the phenomenon using constructs to order the data and relate to earlier literature. Key findings highlight changes in motivations for consultancy engagement, from an initial focus on knowledge (output) to a focus on methodology (process). A new function of intermediaries arises from this study, related with "evaluation of innovation outcomes". The study highlights the contribution of consultancies in preparing companies to innovate.

Keywords. Consultancies; Innovation Intermediaries; Service Companies; Motivations; Collaboration Process, Results.

Cite paper as: Pinto, M., Saur-Amaral, I., Brito, C., (2019). Boosting service innovation: the role of consultancies, *Journal of Innovation Management*, www.open-jim.org, 7(3), 41-68.

ISSN 2183-0606
http://www.open-jim.org

1 Introduction

Innovating is complex, and partnerships with other players in the innovation system are critical to boost companies´ innovation activities. Innovation intermediaries play a critical role in an innovation system, helping to reinforce the innovative capacity of companies, industries, regions and nations (Dalziel, 2010). They facilitate the access to external knowledge of other players in the innovation system, providing information, access and funding (Chesbrough, 2006).

There is a growing literature addressing the roles of innovation intermediaries in manufacturing industry, focused on technological facet of innovation. Yet, in service industry context, this topic is still under explored. Services are of paramount importance in world economies and there is growing literature investigating service innovation. Even though there is not a unique service innovation mode, service companies innovate somewhat differently from manufacturers, focusing on the soft side of innovation and on non-technological innovations (Castro et al, 2011; Tether, 2005). Furthermore, the studies of service innovation have the potential of highlighting features of innovation that have been largely ignored in manufacturing studies (Castro et al, 2011; Drejer, 2004), contributing to a synthesis approach.

To address the literature gap, Pinto et al (2016) proposed a conceptual tool for analyzing the role of intermediaries within service innovation, highlighting the importance of consultancies and universities as innovation intermediaries in service industry. To our best knowledge, this was the first framework describing the functions of intermediaries in services context, and it drew on an enlarged view of innovation (technological and non-technological). In a subsequent empirical study, Pinto et al (2017) confirmed the applicability of the framework within consultancies, using a case study approach to analyze the engagement between service companies and consultancies, from the point of view of the later ones.

Our study aims to contribute to the existing knowledge on the role and importance of innovation intermediaries, more specifically consultancies, in service industry innovation. Using a multiple case study design, and focusing on the perspective of service companies, the research intends to answer the following questions:

1) Why service companies engage consultancies (motivations & expectations)?

2) How do consultancies support the innovation processes of service industry (types of projects, models of engagement, roles & functions of consultancies)?

3) How do consultancies add value to the innovation process of service industry (main contributions; outputs; challenges)?

The paper is organized as follows. Section two includes a brief review of existing literature on innovation intermediaries, with a specific focus on consultancies, and on service innovation. Section three is dedicated to methodological issues. In the fourth section, findings are analyzed and discussed. Section five concludes and section six presents the study limitations and future research propositions.

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2 Innovation Intermediaries

2.1 Importance and functions

Innovation intermediaries are organizations or groups within organizations that work to enable innovation (Dalziel, 2010). As innovation becomes a more open process, intermediaries provide services in three critical areas: information, access to other players and funding (Chesbrough et al., 2006). They bridge the gap between internal and external know-how, reducing the time to market and the time to know-how, increasing the firm´s efficiency in product development and the efficiency of its external service providers (Gassman et al., 2011). They connect different players in the innovation system in order to facilitate the outsourcing of innovation, by reducing the associated costs and by helping to overcome barriers to innovation technologies commercialization (Chu, 2013).

Innovation intermediaries provide many value-adding functions of innovation supporting links, in the areas of IP or technologies trade (Chu, 2013). Their functions may include: Foresight and diagnostics; Scanning and information processing; Knowledge processing and combination/-recombination; Gate keeping and brokering; Testing and validation; Accreditation; Validation and regulation; Protecting the results; Commercialization; and Evaluation of outcomes (Howells, 2006).

Intermediaries can operate has a mediator, in simple or more complex triadic relationships, or they can supply services directly to their clients, without the interference of other parties (Klerkx and Leeuwis, 2009; Howells, 2006). Relationships between intermediaries and their clients tend to be longer, to allow reinforcing mutual knowledge and trust (Howells, 2006).

There is a growing number of studies on innovation intermediaries, with a pragmatic focus. The intermediaries´ functions have been extensively analyzed, yet, the emphasis is on their contribution to the processes of technology acquisition and transfer, on manufacturing context. The literature mostly focuses on brokering role of intermediaries and they are understood as facilitators or mediators in the process of innovation diffusion across organizations and industries (Howells, 2006; Caiazza e Volpe, 2016; Lin et al, 2016; Battistella et al, 2016; Cantú et al. 2015).

A search on the database Current Contents Connect of Web of Science covering the late 20 years (from 1998 to 2017), under the topics “innovation intermediaries” and “service innovation”, revealed that only 3 articles (from a total of 102 articles) were published on journals focusing on service innovation. Furthermore, these three articles address specifically the role of intermediaries as service providers, not analyzing their contribution to service industry innovation. Another search, combining the keywords “innovation intermediaries” and “non-technological innovation”, did not exhibited results.

The intermediation literature bias towards technological innovations limits its application in service industry (Pinto et al, 2016). Service innovation comprehends a lot more than a change in the characteristics of the product itself (Den Hertog et al, 2010), and favors the introduction of organizational and marketing innovations. Besides technological capabilities, human and organizational capabilities are also central for delivering services (Den Hertog, 2010). The bro-

ISSN 2183-0606
http://www.open-jim.org

kering function of intermediaries arguably loses significance in services since the introduction of non-technological innovations (example, a new distribution or pricing system, a new promotion strategy) do not necessarily involve the intervention of third parties and non-technological innovations are usually developed in close interaction with the service provider, in a co-production process.

As service innovation demands for a more enlarged approach to innovation, Pinto et al (2016) proposed a new tool for analyzing innovation intermediaries´ functions in service industry, which encompasses 12 functions of intermediaries (see Table 1).

Table 1. Innovation intermediaries' functions (*Source: Pinto et al (2016)*)

Function
1. Analysis and definition of innovation needs
2. Identification of user needs and major trends
3. Signalization of technological options
4. Conceptualization of new service offerings
5. Conceptualization of new organizational methods
6. Conceptualization of new marketing strategies
7. Identification of potential partners
8. Testing and scaling
9. Selection and training of specialised workforce
10. Protection of innovation assets
11. Accreditation/certification
12. Investment appraisal

This framework considers new and renewed functions of intermediaries, due to its larger understanding of the concept innovation (technological and non-technological).

2.2 Consultancies

There is a large and increasing number and forms of intermediaries (Dalziel, 2010; Howells, 2006), what makes difficult to enumerate all of them. Consultancies integrate this group, and are a privileged service industry partner due to their ease of access, flexibility and diversity of services (Tether and Tajar, 2008; Pinto et al, 2016). Tether and Tajar (2008) highlight that service companies are more likely than manufacturers to involve consultants than other specialist knowledge providers, while their links to public science-base are weaker. Sánchez-González (2014) concludes that cooperation with consultancies favors the development of both organizational and marketing innovations in service companies.

Consultancies are part of KIBS - Knowledge-Intensive Business Services, helping other companies to be innovative (Lemus-Aguilar et al, 2015). KIBS industries are private companies or organizations, relying heavily on professional knowledge i.e. knowledge or expertise related to a specific (technical) discipline or (technical) functional domain, and supplying intermediate products and services that are knowledge-based (Den Hertog, 2000).

KIBS are seen to act as facilitators - when supporting a client in its innovation process, but not creating nor transferring innovation from others; carriers - when transferring existing innovations; sources – when triggering and developing innovations in the client; and also as co-producers of innovation - working closely and interactively with the client, in a two-way learning process (Muller and Doloreux, 2009; Winch and Courtney, 2007; Den Hertog et al, 2010; Miles et al, 1995; Bilderbeek and Den Hertog, 1998). According to Muller and Doloreux (2009), there were changes in how scholars perceive and analyze the knowledge content of KIBS activities since. KIBS are perceived not only as knowledge suppliers but as knowledge co-producers since the appropriation of knowledge by KIBS clients is the result of a re-engineering process performed by KIBS in cooperation with their clients.

Pinto et al. (2017) analyzed the role of consultancies as innovation intermediaries in service industry, through the lens of consultancies. They pointed out that service companies are perceived as somewhat distinct clients when compared with manufacturing clients, namely due to their focus on non-technological innovation and reduced dimension and resources. They also concluded that the brokering role of intermediaries loses importance in service context when the focus is non-technological innovation - when consultancies are working on non-technological innovation, they act as co-creators of innovation, working alongside with its clients.

3 Methodology

The research aims to understand how consultancies support service companies´ innovations processes based on the perspectives of the service companies. It is adopted a multiple case study design which allows to analyze the phenomenon in its natural context and from the perspective of the participants involved in the phenomenon (Yin, 2003; Gall et al, 1996). Case study research design plays an important role in advancing a field's body of knowledge (Merriam, 2009). According to Eisenhardt (1989), case studies are helpful in providing description as well as in testing theory or generating theory. They are considered of particular importance for theory building in areas where existing theoretical and conceptual frameworks are inadequate (Chetty, 1996). In our investigation, due to the emerging nature of the topic in analysis, the case study design allows to provide a rich understanding of the phenomenon of innovation intermediation in service industry, through the lens of service companies.

Purposive sampling was used to select the cases, in line with Eisenhardt (1989)'s argument that building theory from case studies relies on theoretical, not statistical, sampling. Using professional contacts in industry and academia, different cases were identified based on the the criterium that the topic under study was clearly observable and information-rich with respect to the phenomenon under examination. Four organizations were chosen, with prior and considerable experience in consultancy engagement, belonging to private and public spheres, and operating in different and important service industries, to include a diverse set of organizational contexts (see Table 2). The names of the companies have been withheld due to confidentiality reasons.

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Table 2. Cases overview.

Name	Headquarters	Industry	Number of workers
Case 1	Europe	Insurance	200
Case 2	Europe	Public Administration (General activities)	1,500
Case 3	Asia	Public Administration (Tourism activities)	400
Case 4	Asia	Information and Communication	1,100

Source: Own formulation

Previously to data collection, researchers had a preliminary briefing with a key informant nominated by each company, to understand companies´ models of engagement with consultants. They were informed that normally each company has different projects with consultants, and each project is lead and managed by a specific department or division. Consequently, head of departments or divisions were purposefully selected based on their involvement in the companies´ projects with consultancies and due to their broader perspective over company´s projects and challenges (see Table 3). Main data sources are interviews with heads of departments or divisions and top management (executive directors and vice-presidents). In Case 1, the director of Corporate Communications & PR is also one of the executive directors of the company, what allowed a richer testimony. In Case 2, the head of Procurement and Financing Management has a transversal knowledge regarding the usage of consultancies by the other departments, since his department is responsible for the organizations's procurement. In Case 3, it was interviewed the company´s former director due to his extensive experience in the industry. The interviewee managed the company for more than two decades and still works in public administration, in tourism industry. Also in Case 3, the testimony of the senior executive focuses on the activities of two departments (department of organizational planning & development; department of events). In Case 4, the interviews to VPs provided a broader picture of the company engagements with consultants, not restricted to their departments.

The data collection took place between July of 2017 and January of 2018. It was performed 13 interviews, with an average duration of 60 to 90 minutes. Due to time constraints, Case 1 director of human resources requested to present his testimony by writing. It was prepared a questionnaire drawing on the interview guide.

The interview guide was designed taking in account the existing literature on innovation intermediaries and on service innovation. The literature was critical to gain insight to the phenomenon under investigation, and to drive and refine questioning. Due to the exploratory nature of the enquiry, it was built a semi-structured guide, with open-ended questioning, allowing respondents' slack. The guide was oriented around three main blocks: Motivations & Expectations, Collaboration Process and Results (see Fig.1).

Table 3. Data collection overview.

Company	**Industry**	**Departments**	**Collaborators interviewed**
Case 1	Insurance	Information Technologies – Business Applications (BA)	Head of BA
		Finance – Accounting & Treasury (AT)	Head of AT
		Digital	Director
		Corporate Communications & PR	Director / Executive Director
		Human Resources	Director
Case 2	Public Administration (General activities)	Finance - Public Procurement & Financing Management (PP&FM)	Head of PP&FM
		Urban Planning & Development Promotion	Director
		Municipal Works - Studies & Projects (S&P)	Head of S&P
Case 3	Public Administration (Tourism activities)	Organizational Planning and Development	Senior Executive
		-	(former) Director
Case 4	Information and Communication	Strategy & Business Performance	VP Strategy & Business Performance
		Business Quality Assurance	Director
		Legal & Regulatory	VP Legal & Regulatory / Executive Director

Source: Own formulation

ISSN 2183-0606

Fig. 1. Components analyzed in the interviews

Interviewees were asked to identify major innovation projects developed with consultancies and, with reference to those, to describe their motivations and requirements when engaging with consultancies; to characterise the collaboration process (projects characteristics such as duration, stages, teams involved from both parties, main roles and functions provided by consultancies), and to evaluate the results (consultancies´ contributions and difficulties along the process). All interviews were recorded and transcribed *verbatim*.

Other sources of evidence were explored such as internal documents provided by companies, information from websites and media (press and social media) as well as direct observation.

Data analysis was performed using qualitative content analysis, which allows the analysis of text within their context of communication, following analytical rules and procedures, without rash quantification (Mayring, 2000). This type of analysis allows triangulation to occur on two levels: by integrating different data sources; by applying a method of data analysis that has not been mainly developed for case study research (Kohlbacher, 2006). The categories and sub-categories were developed deductively from the research questions and literature review and new categories and sub-categories emerged inductively from the data analysis (see Table 4).

The four cases were analyzed separately and then compared, looking for similarities and differences.

4 Multiple Case Studies: Results

4.1 Cases presentation

Case 1

The company was founded over 30 years ago, being part of a multinational group, and specialising in insurance and risk consulting. It is one of few brokers that works with Lloyd's of London worldwide, having direct access to the world's largest specialized insurance market. The group has direct presence in European, African and South American markets.

Key projects with consultancies

- Internal management platform integrating insurance information from customers and other partners
- Web portal for customers' online management of insurance portfolio
- Introduction of a new ERP system (financial areas)
- Project focused on the creation of a positive corporate culture and sense of belonging
- Training project focused on managing media interlocutors
- Ongoing support (communication issues and events)
- Ongoing support (legislation, human resources matters)
- Training (several areas)

Case 2 The organizations is the municipal council of a county and its mission is to define and execute policies to defend the interests and satisfy the needs of the local population. It aims to promote the development of the municipality in all areas of life, such as health, education, social action and housing, environment and basic sanitation, land use and urban planning, transport and communications, public supply, sport and culture, consumer protection and civil protection.

Key projects with consultancies

- Economic viability studies (to integrate municipal projects eligible for external funding)
- Urban planning studies (eligible for external funding)
- Technical support (such as the support regarding effective communication, through design, in architectural projects; engineering and legal advice)
- Training (several areas)

Case 2 The organizations is a public entity responsible for implementing, analyzing and assisting in formulating market tourism policies. It promotes local tourism products, playing a significant role in fostering the improvement and diversification of tourism products as well as promoting, coordinating or facilitating a variety of tourism projects and mega events. To fulfil its mission, it has representatives and delegations worldwide that tailor make promotion schemes and activities according to each market's needs. As the supervising entity for the local tourism industry, it ensures the sector's operations are under legal framework by licensing and inspecting the establishments, venues and activities. Additionally, it promotes training opportunities for local sectors through collaboration with training institutes and tourism entities.

Key projects with consultancies

- Tourism industry development master plan
- Implementation of local tourism events
- Organizational development studies (preparatory studies about the creation of new entities, new models of partnerships)

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- Events´ impact studies
- Market studies

Case 4 The company is a leading telecom service provider, offering mobile, fixed telephony, fibre broadband and integrated telecom solutions, in consumer and business markets. In activity for more than 35 years, it employs around 1,100 staff. It has introduced in its local market a number of major service innovations such as the first mobile prepaid service, first multi-number SIM service, first 3G service, first and most extensive online service portal.

Key projects with consultancies

- Scenarios´ analysis and strategy definition
- Integrated billing system
- Customer satisfaction surveys
- Tender bids preparation
- Training (several areas)

4.2 Results

Drawing on a hybrid approach, the research started with predefined categories and sub-categories, intended to help guide analysis, and new categories and sub-categories emerged from the data. Table 4 depicts data´s categories and sub-categories and the companies in which they have been observed.

Table 4. Categories and subcategories.

Category	Sub-category	Case 1	Case 2	Case 3	Case 4
Motivations & Needs[1]					
	Information/advice[1]	x	x	x	x
	Access[1]			x	
	Funding[1]		x		
	Methodology[2]	x	x	x	x
	External voice (accuracy, credibility) [2]		x	x	x
Expectations & Selection Criteria[2]					
	Knowledge[2]	x	x	x	x
	Experience[2]	x	x	x	x
	Reputation[2]		x	x	x
	Creativity[2]		x	x	x
	Diagnostic skills[2]	x	x	x	x

Category	Sub-category	Case 1	Case 2	Case 3	Case 4
	Project management skills[2]	x	x	x	x
	Problem solving skills[2]	x	x	x	x
Type of projects[2]					
	Strategical[2]	x	x	x	x
	Operational[2]	x	x	x	x
Model of engagement[1]					
	Dyadic[1]	x	x	x	x
	Triadic or multiple partners[1]	x		x	x
Consultancy roles[1]					
	Facilitators of innovation[1]				
	Carriers of innovation[1]				x
	Sources of innovation[1]				
	Co-producers of innovation[1]	x	x	x	x
Consultancy functions[1]					
	Analysis and definition of innovation needs[1]	x	x	x	x
	Identification of user needs and major trends[1]	x	x	x	x
	Signalization of technological options[1]	x			x
	Conceptualization of new service offerings[1]	x	x	x	x
	Conceptualization of new organizational methods[1]	x		x	x
	Conceptualization of new marketing strategies[1]	x		x	x
	Identification of potential partners[1]			x	
	Testing and scaling[1]	x			x

Category	Sub-category	Case 1	Case 2	Case 3	Case 4
	Selection and training of specialised workforce[1]	x	x		x
	Protection of innovation assets[1]	x			
	Accreditation/certification[1]				
	Investment appraisal[1]		x		
	Evaluation of innovation outcomes[2]			x	x
Results[2]					
	Main contributions (innovation preparation) [2]	x	x	x	x
	Main outputs (improved solutions; some radical innovations) [2]	x	x	x	x
	Deficit areas (market and industry knowledge, interactivity) [2]	x		x	x
	Key critical factor (deliverables) [2]	x	x		x

[1] *Pre-defined categories and subcategories* [2] *New categories*

Source: Own formulation.

We now discuss each one in more detail.

Motivations & Needs

All companies reported engaging consultants because they needed external specialised knowledge or advice, as illustrated in the following quotes:

"This was a major step. We did not have at the time, and we still not have, expertise regarding ERP, so we had to engage consultancies to help us developing our own system." (Case 1- Head of A&T)

"We need to outsource consultancies to do some technical tasks when we do not have the right competence within the company (. . .) Technological issues ae gaining more relevance in innovation. . . and an insurance broker is not a start-up, which develops new technologies." (Case 1 – Digital Director)

"I was given the challenge of developing the local tourism industry, particularly through event creation, and I felt the need to engage consultancies, as specialized entities that provided us advice (. . .) The more unique the event is, the higher is the need for qualified staff. And we were not ready. . . we were aware that if we would have wanted to innovate, we needed specialised advice." (Case 3 – (former) Director)

Additionally, the access to other players was evaluated as important by Case 3 when implementing new types of events:

"Consultancies supported us in the organizations of new events and helped us to get in touch with everyone that mattered. It was a lot of work and we were so small... The value of the consultancy to the development of such a project is enormous, because it allows saving time and money and it is very effective" (Case 3 – (former) Director)

"When organizing a specific type of event (. . .) the consultancy he ensures all contacts with external partners from other countries (. . .)" Case 3 - Senior Executive

Case 2 Head of S&P rejected partially that point of view:

"Consultancies provide us advice which can open new horizons to us and indicate shortcuts. But they usually do not establish bridges between us and other partners. That can happen few times, by instance, when the consultancy has is very well-recognised in the market in which it operates and, as natural process, the contacts are facilitated."

Also, Case 4 reported that they did not engage consultancies to get access to other players, even though consultancies can act as important bridges in technological projects, when implementing of a new technology developed by a technological supplier.

Consultancies' support was found of major importance by Case 2, due to their role in preparing organizational applications for external funding.

Furthermore, service organizations reported that their motivations have changed in some way along the life cycle of the relationship and that, nowadays, go beyond information and advice, focusing on methodology:

"I think that in initial stages we were very much about extracting information and understanding from the consultancy. (. . .) We initially looked for answers: what should we do. But then you wanted to get to plans and implementation and the questions were: how can we do this? how can we avoid this? Definitely, nowadays we look for methodology. And there is a thin line: consultants will guide you but they will not give you the tool box" (Case 4 - VP of Strategy and Business Performance)

"We have learnt a lot from them and based on their survey skills, and on how they ask those questions, we built our own. We learn from them on how they do the data analysis, on how they collect the data (. . .) and now we are doing more than them (. . .) because they don´t have our IT data, they don't have our network data, so they cannot do more" (Case 4 - Director of Business Quality Assurance)

"Often we have the feeling that we are doing all the work. What the consultancy does is to give some structure to our work, creating some focus, providing methodology" (Case 4 - VP Legal & Regulatory)

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"More important than bringing other experiences, consultancies bring methodology. Many times, what is missing in the company is the methodology to manage different topics. And often methodologies can help to share some vision at the executive level, a way to manage doubts, problems, opportunities, risks, ... Often what is lacking is methodology and the consultant can bring methodology to greater effectiveness." Case 1 - Digital Director

"They have given us guidance, recommendations, and inputs about which information we should collect, and how to adjust our documents to be well succeeded in our application to external funding" (Case 2 - Director of Urban Planning)

Companies also reported other motivations related with the need to have an external independent voice over companies' activities. This external voice provides assurance in decision making, contributing to service quality, and, simultaneously, inspires (market) trust. Such view is illustrated in the following quotes:

"(. . .) you have to be a third party to appreciate things. It's like external audits. I have to have the comfort of an independent voice on a certain matter" (Case 4 - VP Legal and Regulatory).

"It is such a big company, and we need a third-party voice. If we just put out our own results, nobody will trust them (. . .) But, if it is coming out from a third party, that is different" (Case 4 - Director of Business Quality Assurance)

"it is important to have international experts to support us, they provide credibility" (Case 3 - Senior Executive)

Expectations & Selection Criteria

All service companies highlighted that their expectations when engaging consultancies were focused on the service provider know-how. The provider knowledge is perceived from different perspectives: technical knowledge but also industry and market knowledge. Furthermore, companies looked up for consultancies well-known worldwide, with an international dimension, that supply information they could trust and gave confidence to the market. The following quotes illustrate these expectations:

"It is important that they know about and industry, and in fact they have that knowledge, but the biggest input they give us is their technical knowledge, their specific expertise" (Case 1 - Executive Director)

"They gave us the report of the knowledge and experiences that they acquire about other places and that they consider useful to us. It was a mixture, on the one hand an attempt to lead us, not let us get off the rails, but, at the same time, to add information and knowledge to the enrichment of the proposal" (Case 2 - Director of Urban Planning)

"The work we do with consultancies is a very technical and specific work, which we cannot do internally since we are not technicians in this area (. . .) We selected a company with international experience, even though they were not profoundly involved in the tourism industry and they did not know well our market (. . .) but here we do not have international consultancies, large consultancies" (Case 3 - Senior Executive)

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"Our market representatives worked as consultancies and they were selected due to their industry knowledge, social networks and reputation. They were respected in the markets hey operated" (Case 3 - (former)Director)

Additionally, service companies remarked that consultancies should be sources of new ideas and insights and should combine strong diagnostic, project management and problem-solving skills. The following comments highlight this:

"It helps us to make diagnoses and confirm and identifies new approaches, new directions, new ideas. It identifies opportunities, and brings a different perspective, external, bringing to the arena less usual doubts. We are always working together within the company, we have a chip, a software to imagine, and it often makes sense to work with an outside consultant who poses new, and sometimes interesting, doubts, from a different perspective" (Case 1 - Digital Director)

"They were actually adding some value, they asked us why we would not do it in a certain way; they were asking us some questions to clarify our line of thinking, and those enquiries led us to question some of our options. (Case 2 - Director of Urban Planning)

"We have to look at innovation from different angles. Innovation could be doing the same thing but differently. I do think that is one of the areas where consultancies are. They are actually a very good source of rethinking things. Tendency on the operational side is for repetitiveness, process. It is always worthwhile to sit back and listen to other people. But it may be not how you will do it but it may spark creative thought on yourself." (Case 4 - VP of Strategy and Business Performance)

"The consultancy does not tell us what we already know. What it will do is to assemble the organizational knowledge that we already have and then apply it to a particular project" (Case 4 - VP Legal & Regulatory)

Type of projects

According to the testimonies, the collaboration processes between the consultancy and the service company can be typified in strategical projects and tactical projects. Strategical projects are long-term projects, related with the exploration of new opportunities, new ideas, mostly focused on definition of strategies and actions, and that impact significantly organizations´s activities; tactical projects are short term-projects, mainly related with the implementation of specific actions or events, aiming to cope with companies´ lack of resources and expertise, and where deliverables are clearly identified a priori. The following comments convey this idea:

"The company had to present a comprehensive report with the analysis of the current situation as well as the definition of strategies, action plans on the short, medium and long term" (Case 3 - Senior Executive)

"The consultancy was focused both on strategy and project implementation, probably 50/50. At the beginning (consultancies work) was mostly about operations and network building. But, the political situation obviously changed (. . .) we used to operate on a concession basis and there was always the possibility (relatively small) that your operations would cease due to government review, and that had to be part of the planning. There was a greater amount of scenario planning

in all bases because we were dealing with a license " (Case 4 - VP of Strategy and Business Performance)

"Several consultancies advised us on how to create and manage specific tourism events. When we thought that it was interesting to create a new type of festival (. . .) we invited the consultancy that was responsible for the implementation of the best world-festival of that type, to come and help us" (Case 3 – (former)Director)

"We need consultancies to outsource some technical tasks when we do not have the right competence within the company. For example, regarding ESO (Engine Search Optimization) marketing, to do the optimization of keywords and development of some landing pages" (Case 1 - Digital Director)

"In my division, there is not much consulting as a definition of a strategy because the inputs we receive (from consultancies) are already very concrete, focused on an object (. . .) but while I was working in planning department, I found that much of this consulting took place "previously" and was not about an object, but on a perspective of evolution of the city, a prospect of development that is intended." (Case 2 - Head of S&P)

The importance of consultancies in the implementation of strategical projects in technological areas was highlighted by some of the companies:

"At a given time point, due to our size and geographical presence, we decided it was time to have our own software to manage our clients´ portfolio that met our needs and was house branded. We started a project with a foreign consultant to create an exclusive management platform which integrates all insurance information from our customers, enabling efficient and effective management processes. (. . .) we also had a similar technological project, we wanted to create a web portal for online management and consultation of all insurance exclusive to our customers." (Case 1 - Head of BA)

"This is a big project and it lasts for a few years already. We are replacing all our four billing systems (. . .) putting everything into one billing system" (Case 4 - Director of Business Quality Assurance)

"(It) will benefit us with significant cost efficiencies, even more important is that it will enable us to deliver a greatly enhanced customer experience, giving our subscribers greater choice and control through accelerated introduction of innovative services and applications, cross-product synergies, unified billing for personalized plans and creative bundling (. . .)" (Case 4 - Press release about the new billing system)

Model of engagement

According to the service companies, mostly of the collaboration projects developed with the consultancies were dyadic, involving direct interaction between the company and the consultancy. Often projects involved not only the department that engaged the consultancy but also other company´s departments, especially in the case of strategical projects. In some projects, consultancies serve as an interface between the company and other players (clients, suppliers, associations, public institutions, private companies, public, . . .), collecting information considered relevant to those projects.

Case 4 emphasized a collaboration project that involved the company (the client), the consultancy as a middleman, and a third-party (the technology supplier):

"The consultancy is responsible for working in-between the product provider and our company and do all sorts of coordinating work and project work for us (. . .) They are working as a consultancy at the same time because they try to understand our requirements and try to use those systems to cope with our requirements (. . .) They have to work with the technology provider to get the results for us" (Case 4 - Director of Business Quality Assurance)

Two companies also reported other models of engagement, in which other type of players actively participated, namely other consultancies. These other consultancies where engaged by the service company or by the main consultancy:

"In fact, there were two external entities, in practice, one more oriented to the consultancy and another to the development of the technological solution" (Case 1 - Head of BA)

"We engaged another consultancy, a local small-sized company, with scholars from the academic side. The purpose of this engagement was to give us support along the whole process. It was not possible for us as technicians to do all this extra-work, monitoring and supervising, since we have other daily tasks to perform (. . .) That second consultancy analyzed the work and reports of the main consultancy, made recommendations, participated in the meetings" (Case 3 - Senior Executive)

Most part of collaboration processes lasted for a long period, typically more than 6 months or even more than one year, and some of the companies pointed out that after the project completion the consultancy continued to provide support, what tended to happen in technological projects. Service companies declare to favor long lasting relationships, which allow the increasing of mutual knowledge and trust, critical elements to ensure the quality of service provisions. Yet, they felt it can result in complacency, jeopardising the ultimate output, innovation:

They have been working for us for quite a long time (. . .) But, personally I am not satisfied with their performance. I want to get ideas from them as an expert. But I usually do not get that from them (. . .) They just work on my requirements and tell me if the new system can cope with them or not. And I don´t need this answer. The answer I need from them is how they can make it work, how can we adjust our requirements to make it work? And I haven't heard anything like this from them. It is a one-way conversation" (Case 4 - Director of Business Quality Assurance)

Consultancy roles

All four service companies perceived consultancies mostly as co-partners in innovation, since they worked alongside with the company to develop shared solutions, in a *win-win* partnership. The following quotes express this perspective:

"There is always a time to learn from someone who is outside. Whether in my case, or in the consultant's own case, these are always bi-directional processes of learning" (Case 2 - Head of S&P)

"This was the first market-oriented development of insurance and mediation in terms of technology. The consultants already had some know-how but not related to this industry. Neither they

nor other consulting companies had innovated in this type of technology in this market. They innovated while developing the solution but also learned (. . .) their know-how became greater" (Case 1 - Head of BA)

"The design (of the tourism plan) was done by the consultant but always supervised by this department (..) In fact, we did not have to be the ones giving the ideas but this consulting company that has to do the study and inform us of the options (...) but we were always making corrections, adjusting their contributions, since they did not have enough knowledge" (Case 3 - Senior Executive)

Case 4 highlighted the role of the consultancies as innovation carriers in technological projects:

"The system is bought from a third party, a billing system provider. This company has a standard billing system but if we use that standard system, we might not be able to adapt it. So, the consultancy is in the middle, they have to think how to build that in the standard system, how to develop a system that meets our requirements" (Case 4 - Director of Business Quality Assurance)

Consultancy functions

All four service companies acknowledge the critical importance of consultancies in the diagnosis and articulation of innovation needs as well as in the analysis of the user needs and market trends.

"The consultancy interviewed various tourism industry companies as well as companies from other industries, other public services, associations as well as the general public to collect the different perspectives (. . .) It was also done an analyze of the city's urban planning, traffic, local capacity to receive tourists, touristic attractions, quality of the local offerings (. . .)" (Case 3 - Senior Executive)

"To create the new application, it was made a thorough examination of the existing processes and needs. Different departments were involved, and some elements of the departments of operations, quality, management control and finances were 100% dedicated to this project" (Case 1 - Head of BA)

Two of the companies, Case 1 and Case 4, pointed out consultancies´ functions in the identification of possible technological trajectories. For both companies the technological innovation has a strategic importance.

In all four cases, companies described the consultancy´s support in the innovation´s design. Case 2 remarked its support mostly in the definition of new services, such as the design of a new urbanistic plan. The other service companies considered that consultancies also helped them in the definition of organizational and marketing innovations. Case 1 pointed out the contribution of consultancies in redesigning the companies´ organizational processes, as a result of the introduction of new management software, and in the conceptualisation of company´s new promotion strategies. Case 3 highlighted the role of consultancies in the redesign of its external network, in the reformulation of internal departments (such as the documentation centre) as well as in the definition of new ways of positioning the brand in different target markets. Case

4 remarked the consultancies´ support at various levels - market research level, concept stores design and definition of customer e-channels.

Case 3 also reported the consultancy support in the identification of relevant partners in the implementation of some new events.

Case 1 and Case 4 focused the consultancies´ support in testing innovations. In both companies created technological innovations alongside with consultancies and it was mandatory to test the new platforms before launching them.

Most part of service companies mentioned that human resources training is critical to service quality and that consultancies have an extensive contribution at this level. Training is focused on technical areas but also on behavioral areas. Case 1 human resources director pointed out an innovative project developed with a consultancy, aiming to create moments of sharing and experience of corporate values in order to reinforce the culture and individual and collective commitment.

Most part of the companies did not get consultancies´ support at innovation protection level. In Case 1, head of BA reported some involvement of the consultancy in the protection of the new management platform. Nevertheless, specialised players in legal and innovation protection areas had to be involved.

Case 3 and Case 4 also reported the consultancies´ support concerning the evaluation of innovation outputs. The assessment of the company's performance and innovation outputs by a consultancy is strategic to redesign services or design new services or new strategies (namely in terms of policies of pricing, promotion, people, ...). Simultaneously, it provides assurance on company's decision making and gives credibility to the market. This is a new function, which is not included in Pinto e al at (2016) framework. The following comments highlight this idea:

"Sometimes demonstrating the obvious to outsiders in a scientific way is not simple. Many years ago we designed and implemented a tourism event of major importance and it brought us large awareness worldwide. Nevertheless, there were enquiries regarding the event´s profitability (...) at that time, I felt we should make a comprehensive and independent assessment of its economic benefits and I engaged an independent company, specialised in impact analyzes. And it was positive, since using scientific methodologies they concluded of the significant impact of this event in our economy." (Case 3 – (former)Director)

"Consultancies are important to our innovation process, helping us to design or redesign services, or our strategies (...) By instance, looking at the results of client's surveys we detect failures which help us to improve certain areas" (Case 4 - VP Legal and Regulatory)

Results

In general terms, service companies perceived consultancies' engagement as important partners to support the improvement of their innovation processes and outputs. Consultancies support was found rather important to prepare the company for innovation. Consultancies support is perceived as more critical in the identification of opportunities than in the innovation implementation, even though they can act as project managers. The following quotes convey this point of view:

"Consultancies gave suggestions and recommendations of what could be some new products (. . .) Some innovations can be implemented, by instance at maritime tourism level (. . .) But the plan does not specify exactly what. This has to be implemented and defined by private initiative." (Case 3 - Senior Executive)

"The consultant works more at the diagnostic level, identifying opportunities, but less on the creation of innovation. It can help in the creation of innovation but as head of project to organize the development of the response" (Case 1 - Digital Director)

"I think that in the end the creation of innovation has to come from the company. The spark or idea may be originated from the consultant. But it has to be taken on, absolutely owned by the company. If that doesn't happen, you are not past to failure" (Case 4 - VP of Strategy & Business Performance)

Consultancies were considered important partners to improve the quality of the companies' service provision, what can sometimes result in the co-development of highly innovative technological solutions:

"The consultancy is always an added value beyond the installed capacity. It is about advice and information that adds value to what we are doing. We are not expecting it to change radically our perceptions but to adjust them slightly" (Case 2 - Head of S&P)

"We e are incredibly innovative, it is our DNA, we are restless, we are always looking for new and different things (...) Having the right partners we greatly enhance our ability to innovate" (Case 1 - Executive Director)

"It was something really innovative produced in-house (. . .) until then, there was no other broker in Portugal with its own software. This stirred our pride indoors." (Case 1 - Head of BA)

Constant interaction between the client and the consultancy was perceived as a key factor to boost collaboration results. In this context, the company has to be adequately prepared to manage and get the best of the interactions. This idea is present in the following quotes:

"Our department was responsible for the interaction with the consultancy team, and there was a department member assigned as project manager. (...) We always had to be supportive, altering, adjusting the contributions because they did not know well our reality" (Case 3 - Senior Executive)

"We have to have the ability to dialogue at a certain specialized level with the consultancies; otherwise, they lead and we do not have control and be drifting from our objectives" (Case 3 – (former Director)

"I am always looking for something more interactive in the beginning so that I can have a better result at the end. Otherwise they will do it the same way and tell us the same things. For me interaction with consultancies is really important otherwise I don't get anything from them" (Case 4 - Director of Business Quality Assurance)

"It should be a dynamic process of inputs and outputs between us and the consultancy. The information comes in, I analyze it critically and then I react to it, demanding the consultancy feedback. I believe there is such care, at least in my area" (Case 2 - Head of S&P)

Additionally, service companies felt that consultancies should know well the specificities of the (clients') industry and of local market, to foster the collaboration results:

"The difficulty of working with consultancies is that sometimes they fail to respond to our needs since they are not aware of our local reality, especially the international consultants (..) They do not understand the local legislation (...) They think they can change things from one day to another but it is not so" (Case 3 - Senior Executive)

"The consultancy should have good knowledge of the client's business: 50% of consultancies knowledge should be about the client's business knowledge, 50% about technical knowledge. However, our experience of contact is not quite that. There is a gap in the market. There are many technical savvy people but they know little about client's industry" (Case 1 - Head of AT)

Some companies remarked the importance of defining precisely the boundaries of consultancies´ support and setting concrete deliverables associated with consultancies´ work. This "tangibilisation of outcomes" is considered important due to the significant costs of the consultancy work. Companies find important to clearly understand for what they are paying for and what will be the ratio benefit/cost. Simultaneously, this clarification is critical to get internal support essential to the project´ success, and in this context it is of the utmost importance to explain to staff the expected results of consultancy engagement to get their support. The following comments convey this point of view:

"Nowadays, we are using consultancy less and differently. The days that we were using it as a big bang project, that you took a fleet of consultants, this tends not to happen so much (. . .) People are wanting to see, literally, deliverables. Ad I think that previously although strategy and reviews and stuff like that were all viewed as useful, in the end there was a feeling that oh, we have done that, but what did we actually achieve?" (Case 4 - VP of Strategy and Business Performance)

"For a long time, we used consultancies as advisors and, simultaneously, as producers of an overall study, and that did not work well. More recently, we are detailing and separating their tasks from ours. We are responsible for the study execution, counting on their input; their task is to provide us guidance, advice, and specific information. This new model works fine." (Case 2 - Director of Urban Planning)

"It is truly important to set the project's aims and expected results (what should be the deliverables)" (Case 1 – Director of Human Resources)

5 Discussion and conclusions

5.1 Discussion

Service companies perceived consultancies as important innovation partners. Due to their small-sized dimension and lack of qualified human resources, they look for the consultancies' support. These service companies engaged a wide variety of consultancies in areas such as strategy, technology, marketing, economy, internationalization, organizational and human resources, engineering, and law. They reported a large diversity of collaboration projects with consultancies. However,

not all collaboration projects targeted innovations, i.e. only part of them aimed to create or improve products or processes or to design new marketing or organizational strategies. Our analysis examined specifically the innovation projects developed in cooperation with consultancies.

It seems rather important to separate the consulting work from services provided by consultancies. The companies interviewed shared consulting experiences provided by consultancies but also by other players, namely the university and suppliers. Consulting work is mostly associated with guidance and advice, and this role can and is developed by other players besides consultancies. Nevertheless, service companies pointed out that consultancies are important innovation partners, due to the quality of outputs and prompt response.

According to the testimonies, the company's industry seems to affect the nature of projects developed with consultancies. Companies belonging to insurance and telecommunications industries reported the consultancy engagement to be of the utmost importance in highly innovative technological projects, usually related with information and communication technologies. These projects were considered strategical for the company's competitiveness. This finding is aligned with previous research, that highlights that service industry includes a wide diversity of activities with different approaches to innovation, and there is not a "manufacturing mode" and a separate "service mode" of innovation (Tether, 2005).

Service companies highlighted as main motives to engage consultancies the need for specialized information and advice. Companies look for providers that congregate technical, industry and market knowledge. The access to other players is not considered a key motivation to collaborate with consultancies, unless when a new specific type event is being implemented. In this situation, due to previous experiences and participation in relevant networks, consultancies are an important partner. Furthermore, consultancies are not perceived as relevant actors in innovation funding; however, they can provide support in the completion of the service company's funding application. These findings are consistent with Pinto et al. (2017) study, which points out that consultancies consider that their important contributions are information and advice.

A key finding is that motivations for consultancy engagement change along the relationship life cycle. In later stages of the relationship, a critical motivation for consultancy's engagement by service companies is related with search for methodology. A consulting methodology provides a frame of reference, structure and a prescribed set of activities and tasks that will be undertaken in a particular and logical order. This type of motivation could be explained by the peculiar nature of services. Service companies´ provision is characterised by its intangibility and variability, and service companies rely on softer strengths at innovation, such as staff's skills and capabilities. In this setting, process management is critical for companies. In this sense, consultancies are a valuable ally, which can help them help to organize their projects into structured, streamlined processes. Additionally, companies' motives to engage consultancies are related with the need for an external voice. Service intangibility underlines the significance of physical cues in service promotion. Therefore, the reputation of the service provider is considered critical to ensure market trustworthiness and companies look for high-reputable providers, namely with international dimension.

The relationships established between service companies and consultancies are usually one-to-one, not involving third parties. The consultancy is not envisaged as a broker, that facilitates

the company's access to third parties and external technologies, but mainly as a co-producer of knowledge alongside with the company. This finding partially supports Pinto et al. (2017) conclusions, which stress that consultancies, when involved in the development of non-technological innovations in service industry, consider that they are more than facilitators of innovation, acting as co-producers of innovations. Yet, in the case of technological innovations, Pinto et al. (2017) concluded that consultancies envisage themselves as innovation facilitators.

Service companies reported that consultancies main functions are mostly related with diagnosis and market opportunities detection, and, simultaneously, they help to define and conceptualise innovations. This finding is also aligned with Pinto et al. (2017) findings, which highlight the importance of consultancies in the diagnostic and conceptualization of non-technological innovation. The importance of consultancies in the areas of training is also highlighted, what is in line with Pinto et al. (2017) findings.

Consultancies provide extensive training to the company's staff, to increase their skills in technical and non-technical subjects. The formal evaluation of innovation outcomes by consultancies is also found important to trigger new innovations. This a new function of innovation intermediaries in service industry which was not covered by Pinto et al (2017), even though it was considered in Howell's (2006) framework. Service companies do not rely on consultancies to protect their innovations, since in this area they engage other specialized players. This finding also supports Pinto et al. (2017) conclusions.

Projects established with consultancies can be of strategical or more operational nature. Service companies pointed out the strategic role of consultancies in preparing the company for innovation. As an external expert, they take a broader perspective and look at the big picture, helping to spot new opportunities, which many times are not obvious to the company. And, even though companies consider that the innovation implementation should be managed directly by the them, consultancies are perceived as a valuable partner in the operationalisation of some projects, when the company doesn't have the necessary resources to do it efficiently. In this situation, consultancies are perceived as important partners at project management level, due to their past experiences, valuable expertise and extensive network.

When evaluating consultancies' contribution, service companies highighted their support in strengthening the overall quality of the companies' offerings. Additionally, they emphasized the consultancies' role in the co-production of radical innovations, namely in technological projects. Pinto et al. (2017) also pointed out that some consultancies felt that their support was more relevant in technological areas.

Regarding the engagement results, service companies find important to associate the consultancies' work with specific deliverables, due to the intangible nature of the provision. The consultancy work is perceived as a provision that essentially involves guidance and advice, and where clients do not ask for a final product. In this sense, the "*tangibilization of outcomes*", through its association to a clear deliverable, is considered essential by service companies.

The quality of the engagement is perceived as being a result of significant interactions between the client and the service provider, and service companies find that they should be well equipped to engage. In this setting, even though long-term relationships are favored, they are also envisaged

ISSN 2183-0606
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as a threat to innovation, since they can result in complacency. Simultaneously, the lack of specific market and industry knowledge by consultancies can endanger the engagement success.

5.2 Conclusions

Our investigation contributes to complement and extend existing knowledge on the role and importance of consultancies as key innovation intermediaries in service industry. Drawing on the framework of Pinto and al (2016), which covers the functions of innovation intermediaries in services, and using a multiple case-study approach, it was analyzed the role of consultancies as intermediaries, through the lens of service companies. Furthermore, our findings allow triangulating and complementing findings of the empirical study of Pinto et al (2017), which focused on the consultancies' perspective of their role as intermediaries.

Firstly, **we conclude that consultancies support to service industry innovation mostly occurs at strategic level.** They are perceived as critical partners in preparing companies to innovate, helping them to spot market opportunities and to define innovation strategies. Their support in the innovation implementation is considered secondary and happens mostly when technological innovation is at stake.

Secondly, **new motivations for consultancy engagement are uncovered, namely related with the search for methodology and credibility.** Innovation literature emphasizes motivations related with the "tangible outputs", such as information, access to other players and funding. But, in later stages of the relationship, service companies look mostly for consultancies' support in structuring their internal innovation processes or promoting their innovation results.

Thirdly, we point out that **consultancies**, as key innovation intermediaries in services, **act mostly as co-producers of innovation, and their brokering role seems to lose importance**. Consultancies support companies in the innovation conceptualization, and are not considered to be bridges to other players in the innovation system. This conclusion is aligned with the first one, since innovation implementation is mostly developed by service companies and, as a result, the contacts with innovation partners are established directly by the companies.

A **new function of innovation intermediaries is suggested, related with the evaluation of innovation outcomes**. This function was not highlighted in those two studies (Pinto et al, 2016, 2017), even though it was included in the framework proposed by Howells (2006). Consultancies help to conceptualize innovations and as well as to evaluate innovations outputs. This finding is coherent with the other findings, reinforcing our conclusion about the importance of the role of consultancies at strategic level.

Finally, we conclude that there is not a unique service innovation mode and these approach to innovation are certainly not unique to services, and can also be found amongst manufacturers (Castro et al, 2011; Tether, 2005). Consequently, **it is important to draw on these findings to ensure the development of a synthesis approach to innovation by pointing to features of innovation that have been largely ignored in studies taking a traditional, technology-focused manufacturing approach to innovation**. (Castro et al, 2011; Drejer, 2004)

6 Limitations and future research directions

Our study deepens the understanding of the role of innovation intermediaries, and more specifically the role of consultancies, in service industry innovation, contributing to the synthesis approach of innovation. The research provides the unique perspective of service clients concerning the role and functions of consultancies in service innovation. This is an emergent area of study and our analysis needs to be triangulated and complemented with further studies.

We developed a qualitative study, that does not allow generalization of findings. It may be interesting to validate our findings empirically, developing an adequate scale for questionnaire-based survey.

Our analysis focuses on four service organizations belonging to different sub-sectors of services industry. Due to the diversity of the services industry, it is extremely important to extend the analysis to other sub-sectors. Furthermore, it is essential to cover other geographical markets, since innovation systems are country-specific.

A big challenge remains in the horizon that is creating a unique framework to analyze innovation intermediaries' functions, which can encompass innovation in service and in manufacturing industries.

This study provides insights into how consultancies and services companies can maximize the outputs of their engagement. On one side, and through the lens of the demand, consultancies can understand the key motivations of service companies to engage with consultancies as well as their expectations. They can learn more about possible models of engagement, consultancies' functions that are perceived as strategic, as well as critical success factors. This insights will allow consultancies to strenghten and improve their offerings. On the other side, service companies can learn from peer experiences, to have a deeper understanding of consultancies' contributions to their innovation processes, namely to non-technological innovation. Tipically, service companies do not have a systematic and comprehensive approach to innovation, and this research offers them an opportunity to enrich their knowledge about the opportunities and challenges of managing innovation in collaboration with third parties and maximize the results of their future experiences.

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Carlos Brito. Carlos Brito is professor of marketing at the Faculty of Economics and Porto Business School (University of Porto) where he has been responsible for managing and directing business programs. He is vice-president of the Portuguese Management Association, member of several advisory boards and Knight of the Port Wine Brotherhood. For seven years he served the University of Porto as Pro-Rector for innovation and entrepreneurship, board member of UPTEC - The Science and Technology Park of the University of Porto, CEO of NET – Business Innovation Centre and president of the General Council of CEdUP - Club of Entrepreneurship of U.Porto. Carlos Brito has a wide experience in the context of the interface university-industry, having conducted projects and studies for both Portuguese and foreign companies and other organisations. He was awarded 'Personality of the Year 2018' by the Business Angels Portuguese Association and was recognised as one of the sixteen "Portuguese Management Masters", a book published by Jorge Nascimento Rodrigues in 2004.

ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 7, 3 (2019) 69-95
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0005
SM: Oct/2018 AM: Jun/2019

Exploring the Creative Industries: Toward a Classification by Process and Job Functions

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Abstract. In Europe, the creative industries (CIs) are experiencing growth rates well above the average of the EU's total economic growth. However, a lack of consensus regarding how these industries work impedes the development of effective policy. In our research, we suggest a process approach to characterize the CIs. This characterization is more flexible in comparison to existing definitions. This process model can be used to easily identify job functions that are important for the development of innovative and creative products or services. Twenty-three semi-structured interviews were conducted with key players in the CIs in the Netherlands. After analysis of these interviews, a process model was developed that consists of the following six steps: (1) problem analysis, (2) concept generation, (3) provisional design, (4) final design, (5) production/execution, and (6) product introduction. This model was supplemented with job functions for each step of the process. For future research, the model should be further developed to provide a greater differentiating effect between the CIs and other industries. However, the model can be very useful for characterizing the CIs in a manner that is more adaptable to the ever-changing nature of these industries.

Keywords. Creative Industries; Creative Process; Job Functions; Characterization.

Cite paper as: Koehorst, M., van Deursen, A., van Dijk, J., De Haan, J., (2019). Exploring the Creative Industries: Toward a Classification by Process and Job Functions, *Journal of Innovation Management*, www.open-jim.org, 7(3), 69-95.

ISSN 2183-0606
http://www.open-jim.org

1 Introduction

Worldwide, the creative industries (CIs) are growing in terms of both value and the number of professionals working within the sector. According to the European Union (EU), the CIs have been experiencing a growth rate more than four times the EU's total average growth (KEA European Affairs, 2006), which indicates the importance of the CIs to the economy (UNCTAD, 2010). Therefore, governments worldwide are developing policies to help these industries remain competitive in an international and globalized market. However, to achieve this goal, a clear understanding of what characterizes the CIs is required. Currently, the CIs are primarily characterized in terms of specific professions, such as film director, editor, or architect (Urlings & Braams, 2011), or industrial lines, such as broadcasting, performing arts, and advertising (Department for Culture Media & Sport, 2014; Ministerie van EZ & Ministerie van OCW, 2005). Because innovation is a key component of the CIs, these professions and industries are constantly evolving, which makes the CIs dynamic and fluid. Due to rapid innovation, products and services are introduced that would have seemed inconceivable just a decade ago; new technologies and applications are rapidly emerging. Among other things, these technologies are used to make business processes more efficient in a wide variety of sectors. This is why creativity and innovation are increasingly interwoven with other industries, which makes it counterproductive to use existing industrial lines to define this sector.

As past efforts to classify the CIs have severe limitations, Jones, Lorenzen, and Sapsed (2015) made a differentiation based on types of change. They argue that sectors within the CIs can be divided according to their response to different drivers of change. The types of change are "*Preserve* (slow change in semiotic codes and material base), *Ideate* (fast change in semiotic codes but slow change in material base), *Transform* (fast change in material base but slow change in semiotic codes), and *Recreate* (fast change in semiotic codes and material base)" (Jones et al., 2015, p. 13). An important driver of change is public policy. Preserve, as a type of change, is mainly concerned with sectors that can be described as cultural heritage, such as museums, and institutions for orchestras, ballet and opera. However, policy is becoming more concerned with the optimization of creative and human capital. The reciprocity of knowledge and spillovers to the wider economy become increasingly important as objectives of policy (Bakhshi, Cunningham, & Mateos-Garcia, 2015; Cunningham & Potts, 2015). For this reason, it is important to understand what kind of professionals work in the CIs, and what skills they need to reach their full creative potential.

The current structures used to delineate the CIs make it difficult to write such policy. Industries are often named after the principal product they produce. Apart from creativity, the commonality that merge the different industries in the CIs together, is unclear. Until this date there is no uniform consensus about the term creativity, which makes delineating of this sector even harder. In this paper, we explore how the CIs can be characterized without using strict and arbitrary industry lines or job functions. Alternatively, we suggest a process orientation to characterize the development of innovative products or services in the CIs. This process is supplemented by both creative and non-creative job functions needed in each phase. Understanding the process of creation is vital in understanding what job functions and the related human capital is needed to be creative and innovative in the modern workplace. By defining a process to which job functions

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can be linked, all professions involved in the creation of innovative products or services are considered, not only those jobs that are creative at their core. By doing so, not only will creative professionals be included, but a clearer overview of all professions that add to the economic value of the CIs will be achieved and human capital in the CIs can be adequately improved and utilized where needed. In addition, we believe that this approach to the characterization of the CIs is more dynamic and can capture the essence of this ever-changing sector. To help write policy for industries, besides those defined as cultural heritage, we aim to address the following questions:

- What work process characterizes creation and production in the creative industries?
- What are the job functions needed to successfully support this process?

To answer these questions, a set of semi-structured interviews were conducted with key players in the Dutch CIs. By answering these questions, we hope to gain better understanding of the CIs.

2 Theoretical Framework

2.1 Creativity and Creative Industries

Creativity is a much sought-after asset in workers in almost any industry, from automotive and advertisement to logistics and agriculture. However, the degree of creative intensity varies among the diverse professions in these industries. Furthermore, the understanding of creativity fluctuates within different contexts. Depending on the profession and industry in which people are employed, their idea of what creativity entails is likely to differ. Given the numerous definitions of creativity and the diversity of organizations and workers in the CIs, finding consensus on what should be considered part of this sector is a complex endeavor.

In scientific literature, the debate over a standard definition of creativity has been an issue since the middle of the twentieth century. Parkhurst (1999) claims that the lack of consensus about the definition complicates not only our understanding of the CIs but also the development of sufficient policy for nurturing creativity in students who are supposed to interact in the work environment of the twenty-first century. According to Runco and Garrett (2012), Stein (1953) provided the first "standard" definition of creativity, which combines two elements: (1) originality (e.g., innovation, novelty) and (2) effectiveness (e.g., fit, appropriateness). In this definition "effectiveness" is described as "a solution to a problem; a completed, communicable idea; or something tangible like an invention or work of art" (Parkhurst, 1999, p. 17). These two key elements seem to have been generally adopted by scholars and are combined in the definition of Amabile, Conti, Coon, Lazenby, and Herron (1996): "the productions of novel and useful ideas in any domain" (p. 1155). This definition is therefore often adopted by scholars in creativity research (e.g. Ernst, Hoyer, Krafft, & Soll, 2017; Sarooghi, Libaers, & Burkemper, 2015).

For the development of policies, however, a formal definition of creativity is not used as a starting point to understanding the CIs. Every country concerned with stimulating the CIs has its own framework for defining it, which is often based on industrial lines (Bakhshi, Freeman, &

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Higgs, 2013; Braams, 2011; Department for Culture Media & Sport, 2015; Ministerie van EZ & Ministerie van OCW, 2005). However, due to spillovers to other industries, it is difficult to measure policy. The creative economy is more complex than the sum of these industries and might drive change throughout the whole economy (Potts & Cunningham, 2010; Potts, Cunningham, Hartley, & Ormerod, 2008).

2.2 The Origin of the Creative Industries

Since the development of the first DCMS mapping document (DCMS, 1998), the "cultural economy" has been gradually replaced by the creative economy. This change has promoted discussion about whether activities that are termed "cultural heritage" should be included in the definition of the CIs. Potts et al. (2008) note that the CIs are now classified on industrial lines, which is "an extension of the *cultural industries* definition to incorporate the *copyright industries*" (p. 2). This has remained unchanged since the first outline of the DCMS mapping document in 1998. However, this definition is too vague and inadequate to characterize the CIs (Flew & Cunningham, 2010).

Nesta (2006) states that the purpose of the CIs is to exploit creative capital for commercial gain. This view is supported by Jones et al. (2015): "Even if there are elements of creativity in most human endeavor, not all industries are organized principally to take advantage of and capture the market value of human creativity"(p. 2) and UNCTAD: "(. . .) they [the CIs] comprise the cycle of creation, production and distribution of goods and services that use intellectual capital as their primary input" (2008, p. 5). UNCTAD underlines this concept by claiming that the services and goods produced by the CIs—in addition to creative content—should have economic value and be capable of being marketed (2008). This view clearly differs from the domain of "arts and cultural heritage" according to Rutten, Koops, and Roso (2010), who state that economic motives are subsidiary to the artistic motives and a certain aesthetic need. However, the importance of economic value for the CIs is also emphasized by Yue (2006), who explains that the CIs are essential to strengthening a country's competitiveness in global markets. These arguments show that there is an ongoing discussion about what to include in the CIs. Nevertheless, there is agreement on the inclusion of the following industries: publishing and literature; performing arts; music; film, video, and photography; broadcasting (television and radio); visual arts and crafts; advertising; design, including fashion; museums, galleries, and libraries; and interactive media (Flew & Cunningham, 2010; UNCTAD, 2008). This outline clarifies that, although different efforts have been made to characterize the CIs, it is complicated for scholars and policymakers to depart from the original approach of classification by industry. It also emphasizes the need for an approach that makes it possible to write policy to improve the human and creative capital of professionals in the CIs that goes above and beyond cultural heritage and industrial lines.

To develop a flexible process characterization of the CIs, however, a starting point must be established. So, to obtain a better understanding of what transpires in the CIs, we use the definition of creativity provided by Amabile et al. (1996) as a starting point for our study: "the productions of novel and useful ideas in any domain" (p. 1155).

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2.3 The Creative Process

Creativity is at the core of the CIs, which UNCTAD (2008) describes as organizations that create, produce, and distribute services or goods with economic value for which intellectual capital is the most important input. Nonetheless, little has been published on the subject of a creative process to characterize organizations, let alone sectors. To date, the creative process as described in the literature focuses primarily on individual creation, which often follows the "four-stage model creative process": (1) preparation, (2) incubation, (3) illumination, and (4) verification (Guilford, 1950). However, Lubart (2000-2001) acknowledges that this model may need revision because it has been superficial since its conception. To define creativity, Torrance (1965) used a process approach in which the "sensing of difficulties, problems and gaps in information" (p. 8) is necessary to define and solve a problem. This is often referred to as problem analysis, which is considered essential for finding an adequate solution to a problem. When insufficient time is spent at the problem-analysis stage, there is a high risk of error (Römer, Leinert, & Sachse, 2000). Bannerot (2003) further stresses the importance of problem analysis by stating that to obtain a clear overview of the client's needs, the process should entail (1) clarification of objectives, (2) establishment of requirements, (3) identification of constraints, and (4) establishment of job functions. The downside to the process-description of creativity by Torrance (1965) is that it does not differentiate between a typical creative endeavor and, for instance, a scientific one (Parkhurst, 1999).

Caniëls, De Stobbeleir, and De Clippeleer (2014) describe how different stages of the creative process require different incentives to maximize employee creativity. They summarize creativity as a process with three stages: idea generation, idea promotion, and idea implementation. In idea generation, multiple concepts are generated that might be possible solutions to a problem at hand. According to Wang (2013), this phase of concept generation—although very important—is typically characterized by a lack of structure. Although the approach of Caniëls et al. (2014) incorporates implementation and therefore has a wider scope than the model by Guilford (1950), it is still too limited for the purposes of this study because it focuses on individual creativity. Because a key component of the CIs is the economic value of marketable products, this aspect should be included in our process model.

2.4 Job Functions

The skillset required from workers in the twenty-first century is vastly different from the skills needed during and after the industrial revolution, which were focused on manual labor to a much greater extent. In current western society, knowledge—and the ideas generated with this knowledge—are seen as commodities (Anderson, 2008; UNCTAD, 2008). This principle of human capital and the knowledge and ideas of workers are a significant component of a successful creative organization. Knowledge is indispensable for innovation and development and therefore is directly correlated with economic growth (David & Foray, 2003). This is why the CIs are seen as one of the sectors where great economic growth can be accomplished. Consequently, policy designed to support the growth of the CIs should be based on a clear understanding of these industries and of the people who work in them.

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Another method chosen to characterize the CIs is to approach this characterization from the perspective of the creative professional. Urlings and Braams (2011) counted the number of professionals working in job functions classified as creative because these professions are deemed important for stimulating economic growth. Bakhshi et al. (2013) proposed a focus on "creative intensity", which is the percentage of creatively occupied jobs in a sub-industry in comparison with the total number of jobs in that industry. However, for a complete overview of the economic value of the CIs, focusing on creative job functions is not sufficient. With these methods, the dynamic value of the CIs remains unclear because there might be many professions that are not classified as creative but that nevertheless play a crucial role in how a creative product or service transpires.

3 Method

Because very little scientific literature addresses the characterization of the CIs using a process approach, explorative research with qualitative methods of data collection and analysis was chosen for this study. Semi-structured interviews were used to gather information about the processes in CI organizations and the job functions that are important in this process.

3.1 Research Setting: The Dutch Top Sector Creative Industries

This study focuses on the Dutch CIs as one of nine knowledge-intensive sectors that receive special attention from the Dutch government and for which directed policies are developed to simulate growth. In the mapping document for creative activity in the Netherlands, which dates back to 2005, the CIs are classified as a collection of industrial segments in which a major part of the creative production occurs (Ministerie van EZ & Ministerie van OCW, 2005). A division among three categories is proposed: (1) arts, (2) media and entertainment, and (3) creative and business services. Each of these categories is further divided into four stages: initial creation, production, distribution, and retail. These four stages are used to define a broad classification and a limited one (see Appendix A). As a starting point, the limited classification of the ministries of EZ (Economic Affairs) and OCW (Education, Culture and Science) (2005) was used (see Appendix A) because these are the organizations in which the creative process occurs and, as previously mentioned, there is a consensus on the industries included in this classification (Flew & Cunningham, 2010; UNCTAD, 2008). Although we attempt to find a more dynamic classification of the CIs, this classification helped us to achieve the necessary variety within the sample.

3.2 Sample

The study focused on key players in the Dutch CIs. A list of different industries in the creative sector was constructed, after which potential participants were selected using LinkedIn and the researchers' personal networks. For the final selection, *criterion-based sampling* was used to ensure that every element of interest for the research was covered. More specifically, we used *maximum-variation sampling* so that each of the different constituents of the CIs was included

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(Ritchie, Lewis, & Elam, 2003). A total of 23 interviews were held with 24 participants. Of the participants, 33.3% were female (n=8). Among these were CEOs/founders (n=8), working professionals (n=3), HR managers (n=2), recruiters (n=2) and board members (n=2). Participants working in the following industries were included: media, advertising, graphic design, game development, software development, publishing, architecture, Dutch design, journalism, music, and fashion (Table 1).

Table 1. Industries and Job Functions interviewees

#	**Industry**	**Function interviewee**	#	**Industry**	**Function interviewee**
1	Overarching	CEO	12	Publishing/media	Managing dir.
2	Architecture	Founder/CEO	13	Publishing/media	HR chief
3a	Architecture	HR manager	14	Media	Manager
3b	Architecture	Business Developer	15	Advertising/media	Founder/CEO
4	Architecture/education	Board member	16	Advertising/media	Film director
5	Education	Board member	17	Fashion	Founder/CEO
6	Education	Head of dept.	18	Fashion/education	Head of dept.
7	Education/gaming	Head of dept.	19	Textiles/design	Founder/CEO
8	Gaming	Founder/CEO	20	Music	Programmer
9	Serious gaming	Recruitment man.	21	Music	Founder/CEO
10	Serious gaming	Founder/CEO	22	Journalism	Independent
11	Publishing/media	Interim director	23	Museum	Interim director

3.3 Procedure

After selection, participants were contacted via e-mail to make an interview appointment. A semi-structured interview approach was used to collect information. By doing so, open-ended questions could be adapted to the participants' specific industry. Of the 23 interviews, 22 were individual interviews (with one participant). The interviews were recorded and later transcribed.

Every interview began with the recording of informed consent, after which the first author asked the participant to describe the company in which he or she worked and the kind of work the participant did for the company. As the interview continued, the questions focused on processes and job functions. After the introductory questions, participants were asked what kind of products or services they provided and how these were developed. Participants were asked to draw the process of product creation on a sheet of paper. This drawing served as a guideline throughout the rest of the interview. After the process was drawn and discussed in depth, participants were asked what job functions or professions could be linked to the different steps of the process. These professions were written on blue pieces of paper and were placed near the corresponding steps of the process.

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3.4 Data Analysis

All interviews were transcribed and then coded with the use of ATLAS.ti. Content analysis was used to derive a codebook. The codebook contained all codes subdivided into themes. The themes were mostly predetermined by the interview questions (i.e., process, job functions, CI) (see Appendix B). These themes were used to categorize the codes, which were extracted during content analysis on basis of the interviewees' answers (e.g., the code "designer" was added to the theme "job functions" when an interviewee mentioned a designer as someone who worked in the CIs). These codes were added to quotes referring to the construct of the code. After the content analysis, relational analysis was used to identify similarities in coding and merge overlapping codes. The analyses of the 23 interviews resulted in 8 themes with 138 codes (Table 2). A ninth theme (*steps*) was added to connect the different steps of the process, as mentioned by the participants, to a number to achieve an order in the steps. Some of the themes had multiple subthemes to differentiate several concepts and contextual elements (see Appendix B). The interrater agreeability between two raters had a Cohen's Kappa of .67.

Table 2. Themes of the codebook with the number of subthemes and labels

Theme	**# of subthemes**	**# of labels**
Creativity	0	3
CIs	2	12
Culture	0	4
Job functions	3	34
Organization	0	9
Other	0	1
Process	4	43
Skills	5	27

4 Results

In the following section, the results of the interviews are discussed based on the concepts of the process and job functions.

4.1 The CI Process Model

Based on the content analysis of the interviews and the drawings, steps in the work process within the CIs could be distinguished. Because a characteristic of the CIs is adding economic value, these steps involve the introduction of products into the marketplace. The steps are elucidated here.

Problem analysis.

Problem analysis was often mentioned as an important prerequisite for a successful creative process. Without a clear definition of the problem, it is unlikely that the final product will meet the client's expectations. Participants explained that the problem analysis stage helps to define the exact question of the client and therefore the relevant problem to be solved. Clients frequently have a fixed idea about what the solution to the problem should be, even before the design process has begun. Problem analysis helps to focus on the final goal instead of the way in which this goal is achieved. During problem analysis, all pieces of information are collected. According to the participants, a characteristic of creative problem solving is that many options for solving one problem are explored, so having all the information is crucial. As one of the participants put it,

> *"In general, they* [the clients] *say, 'We want X', and a firm then says, 'Are you sure you want X?' 'Yes'. 'I think you have a problem that you could want to solve with X, but it could also be something else'. So, yeah, maybe that is more or less the difference between knowing you buy bread or somebody saying, 'You are hungry, that is the problem, and maybe you want bread, or maybe something else'."*

Respondents indicated that in the creative process, the solution starts with determining the "right" problem. This is not always clear to the client, even though the client might think it is.

Concept generation.

Participants suggested that concept generation starts with sketches or rough ideas that have been generated in response to the needs and criteria that are derived from problem analysis. They stated that during the concept generation stage, various directions are explored:

> *"... on the basis of the analysis, you will often go to the concept phase, in which different directions are developed".*

With the help of the output of problem analysis, initial sketches or manifestations of what the final result could be are developed without going into detail. A concept expresses the idea that eventually should be conveyed to users once the product is completed. It is the first step toward the final idea. It is common for multiple concepts or ideas to be explored during this stage. A combination of concepts can be applied in the finalized product. In general, during the concept generation stage, there are very few limitations. Because everything is still open and all options can be explored, this is where creativity can flow most freely and creative intensity is at its peak.

Design.

Design was often divided into multiple stages by the participants. Whereas during the concept generation stage various ideas are given a rough form or are sketched, in design, one or more of those ideas is further explored and perhaps executed. The participants used many different names for the design stages, such as schematic design, provisional design, technical design, contextual design and final design. However, almost all of them made a distinction between the first phases of design, in which more freedom was permitted and ideas were not yet set in stone, and the stricter final design, in which details were worked out and the design was finalized before it went to the production, execution or engineering phase (Fig. 1).

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> *"... with a concept design (...), that is more or less the dating phase: (...) are we the right match? And if you conclude, we want to date each other, then you are going to objectify that [the concept design]. Then you make a schematic design, which means you have clearer objectives..."*.

Iterations.

Iterations are represented in the model by the arrows moving in different directions (Fig. 1). Iterations are loops in the process; developers are continuously testing and altering the product. While doing so, much of the initial ideas might perish. Iterations were often mentioned in combination with "scrum" or "agile development", methods that are used in the CIs. As one of the interviewees explained:

> *"Iterations is THE keyword in the creative industries. (...) You just start very small, you make something, you test it, you improve it, you test it, you improve it, you test it, you improve it, you test. So you go in short loops towards the endpoint".*

Iterations mostly appear in the concept generation and design stages, although during design, it might be beneficial to go back to the problem analysis stage to obtain extra information

Production/execution and product introduction.

As previously discussed, the CIs are characterized by the ability to achieve commercial gain by marketing novel and useful ideas. This is why the production and execution of the designs and the introduction of those products into the marketplace are a crucial part of the creative process for the CIs. Without a successful and well thought out introduction of those products, the CIs would cease to exist. Indeed, part of the CIs' activities is to creatively market products or services for clients. As this interviewee described it:

> *"What does a creative person do? They work on an assignment and at some moment it is finished, 'Oh, the assignment is finished. What should I do next?' There is another process behind it, among others, business development."*

Companies specializing in marketing products for clients go through all the steps of the process themselves to introduce these products into the marketplace. In these instances, the end result of the process is not the client's product but the marketing campaign created by the company. As the product nears finalization, creative intensity degrades because the choices made are more definitive.

Considering all these steps, a model of the process derived from the interviews and drawings is shown in Fig. 1. As shown in Figure 1, the start of the process can be either triggered by *demand* from either a client or the market, or by *opportunities* from the market or society.

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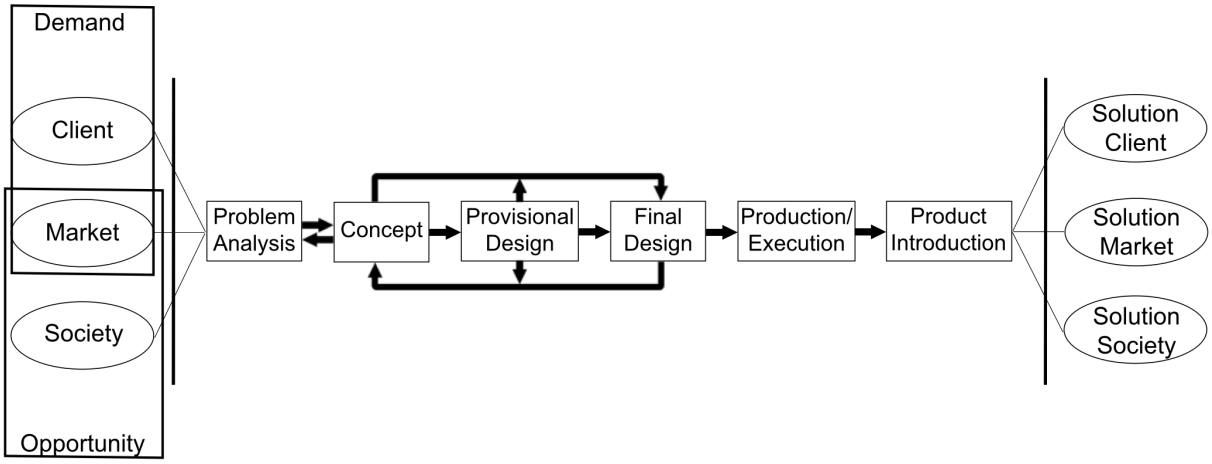

Fig. 1. Process model characteristic for product or service development in the CIs

4.2 Job Functions

Since the kind of sectors included in the CIs display a lot of differentiation in the principal products they produce, the job functions found within these sectors differ greatly. However, some overlap in groups of job functions can be found, even though the manner in which these jobs are performed, and the products they produce are un-alike. To group these job functions, we compared the job functions mentioned by the respondents with the creative job functions as summarized by Urlings and Braams (2011). With this comparison, a few things stand out. The job functions Urlings and Braams (2011) characterize as creative are divided in three categories, namely arts, media and entertainment and creative and business services. The third category is predominantly related to job functions in architecture and urbanism. However, a great deal of the job functions included by Urlings and Braams (2011) were described by the respondents as less creative, or even non-creative. Examples are: constructor, engineer or managing partner. In other categories Urlings and Braams (2011) included job functions that were characterized by the respondents as non-creative, mainly with regards to project management for film, publishing and new media, and more executing job functions like programmer or engineer. Furthermore, many functions named by respondents were not even included: job functions related to game design – either for entertainment or serious games – and job functions related to fashion design were absent in their framework.

Table 3. job functions mentioned by respondents and their corresponding job function group in the model

job function group in model	**Examples mentioned by respondents**	**Sector**	**Corresponding job function by Urlings and Braams (2011)***
Designer	Artist	Gaming	-
	Game designer	Gaming	-

job function group in model	**Examples mentioned by respondents**	**Sector**	**Corresponding job function by Urlings and Braams (2011)***
	Visual designer	Gaming	-
		Marketing/media	Book illustrator, lightning sketcher, decor-, marketing-, graphic designer (intermediate)
	Fashion designer	Fashion	-
	Textile designer	Fashion	-
	Architect	Architecture	Urbanist; architect, construction engineer
	Architect (Interior)	Architecture	Interior designer; architect, construction engineer
	Architect (Landscape)	Architecture	Garden- and landscape architect
	Interaction designer	Marketing/media	-
		Gaming	-
	Photographer	Marketing/media	Photographer, film- and tv-camera operator, film editor or mechanic, photo laboratory operator (intermediate)
			Instrumentalist, composer, conductor (excl. choir), songwriter
	Sound designer	Gaming	-
	Curator	Museums	-
	Composer	Music	Instrumentalist, composer, conductor (excl. choir), songwriter
Strategist	Strategist	Marketing/media	-
		Gaming	-
	Business Developer	Architecture	-

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job function group in model	Examples mentioned by respondents	Sector	Corresponding job function by Urlings and Braams (2011)*
	Researcher	Gaming	-
	Booker	Music	-
Project Manager	Production assistant	Television	-
	Content manager	Publishing	-
	Film director	Film	Director theatre, film
	Floor manager	Film	-
	Art director	Marketing/media	-
		Gaming	-
		Fashion	-
	Creative director	Film	-
	Project manager	Gaming	-
		Architecture	-
		Museums	-
	Producer	Marketing/media	-
Engineer	Programmer	Gaming	-
		Marketing/media	-
	Construction engineer	Architecture	Designer-constructor
	Installation engineer	Architecture	Designer-constructor energy, telecommunication technique, electric motors, electronics
	Knitting specialist	Fashion	-
Marketing Manager	Marketer	Publishing	-
		Museums	-
	Sales manager	Publishing	-
	Sales director	Fashion	-

* If applicable.

Some of the job functions were absent in the framework of Urlings and Braams (2011), this could also be due to the fact that some of the job functions as mentioned by the respondents were considered to be non-creative.

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Professional creativity.

To be able to connect job functions to the different stages of the model, we first need to obtain an understanding of the degree of creativity for the involved professionals. Therefore, we take a closer look at what is viewed as a creative professional.

As noted by many of the interviewees, creativity is a skill or trademark that is desired in most, if not all, professionals in the twenty-first century. In that sense, it should be used in the general line of work. Most interviewees responded to the questions about which job functions they considered creative by stating that it is preferable for all employees to possess some degree of creativity to help them with their daily activities. Initially, they felt reluctant to appoint certain job functions as being more creative than others:

> *"... I actually think that, of everybody who works for us, a certain degree of creativity is required (...) Except for the bookkeeper—that is somebody we don't need because of his creativity—but for all the production-oriented people, (...) we expect a certain degree of creativity".*

For creative professionals, creativity is the aspect that makes them successful; it is the aspect around which their jobs revolve. It is why clients come to them: to think of something no one else had thought of. Participants noted that some clients tend to take the place of the designer, making the creative professional an executor instead of a creator and innovator. However, being the innovator and not the executor is a very important trademark of the creative professional.

To discover what they viewed as truly creative, the participants were asked to give their own definition of creativity. Many interviewees mentioned "out-of-the-box" as a phrase that instantly came to mind when asked about creativity. Almost all participants mentioned creation or finding new solutions as an aspect of creativity, although none of them referred to both innovativeness and effectiveness as key factors of creativity. The closest to a definition was given by this participant:

> *"Creativity is a part of the creative/artistic process. Creativity means that you are able to make a new composition from an existing context and situation. So that is actually the creative part in it. But it is also, in the artistic/creative process, there is also a part—if you are talking about the development process—that is just repetition and doesn't have anything creative in itself. (...) But the creative moment itself is the moment that you take existing elements and make something that is new to you".*

Participants acknowledged the difference between creativity being at the core of someone's profession and creativity as a skill to be better at a job. Thus, a distinction can be made between "creative job functions" (e.g., designers, researchers, strategists, art directors) and "non-creative job functions" (e.g., producers, project leaders). Even though all job functions are equally important for efficient product development, most non-creative job functions (with the exception of the project leader) could be viewed as supporting or executive roles.

Creativity was considered a more important skill in the beginning of the process, when new ideas had to be generated. As the process of development continues, the margin for creativity diminishes and the more execution-related job functions (i.e., functions that realize the ideas conceived in earlier stages of the process) begin to play a larger role.

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The CIs' Process Model Supplemented with Job Functions

In the following section, the process model described earlier is supplemented with the job functions mentioned by the interviewees. Considering the breadth of the CIs, these job functions are formulated as groups with a common underlying incentive.

Problem analysis.

Job functions involved in this stage, according to the participants, are business developers, strategists and researchers who determine what information is needed to successfully execute the project. These job functions might be executed by the same person—or possibly even the designer—depending on the size of the organization:

> *"... that job function is just united in one person in the way I just said. It is, however, often the case that the analysis is performed by people who actually understand how you can build something after that."*

When problem analysis is completed, a team can be assembled that will design and develop the solution. If a project manager is appointed, he or she will be involved in this stage of the process as well.

Concept generation.

In this stage, creativity can flow freely. This is where creative professions such as designers come up with multiple ideas, only loosely guided by project management.

Design and production/execution.

Depending on the product or service developed, designers, architects, game designers, or art directors are most involved in these stages. Engineers are involved in this stage to begin the execution of the product. Through iterations of design and production/execution, designers and engineers work together. As the process continues—from concept generation, to provisional design, to final design—the degree of freedom for creativity becomes increasingly restricted. However, through iterations, the product is continuously tested, analyzed and improved, so the degree of freedom and the people involved might be dynamic.

> *"So, that constructor, he will say, 'I want concrete pillars. And I want concrete beams, or steel beams'. Give those to his engineers, and they will incorporate that in that model. Those get slid into each other. Every week it gets taken apart and put together again. And this is how the design gets developed further".*

As another example of how different job functions are connected to different steps of the process, depending on the degree of finalization of the product, one architect said:

> *"We [the architects] are very focused on the concept phase, and the co-architect is actually more focused on the execution phase".*

Product introduction.

The product introduction-phase is concerned with introducing the finalized product into the market. The importance of this step was emphasized by this interviewee:

> *"I think product development is real creation, but my eyes have really been opened the last*

few years to what creativity means if you are talking about graphics and about marketing because for me, this all has to do with the same thing. That is, somebody sees something, feels something, that it gives you a warm feeling—to keep it vague—ultimately making you want to buy the product or use it. And that is, on the one side, dependent on the product, but since we founded [the company] and did the whole branding, the way in which we started selling, that really made a difference in how people look at you as a brand and, yeah, we really saw a difference between the old branding and the new branding and what it adds to the fact that your product is just interesting. (. . .) I think that that branding (. . .) resulted in more conversion".

This statement shows that to generate value, introduction into the market and the way a product is branded are very important. This is why strategists and marketers are important for economically thriving CIs.

A general overview of what job function groups play a role in the different steps of the creative process model is shown in Figure 2.

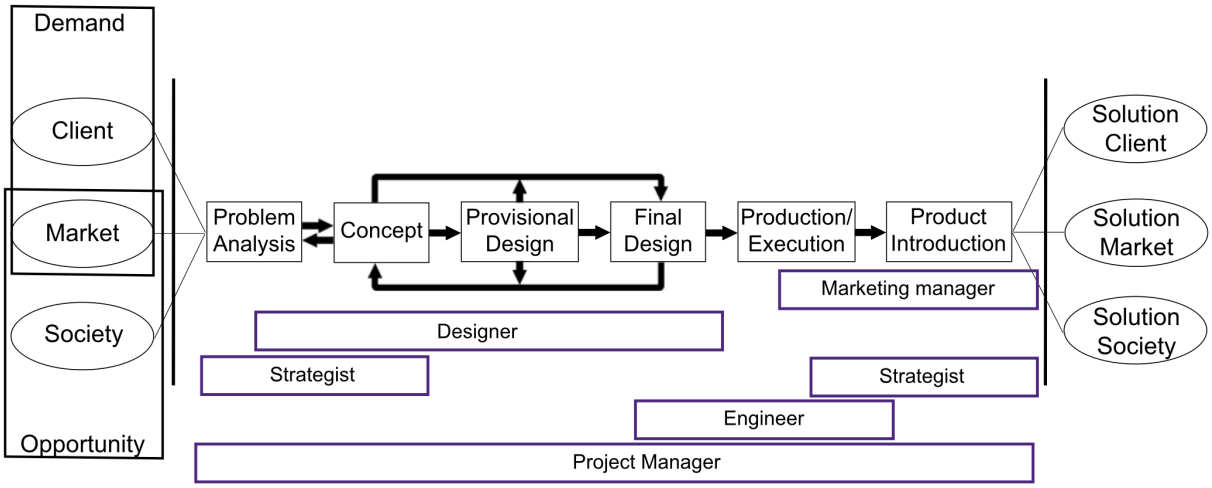

Fig. 2. Process-model supplemented with job function groups.

5 Discussion

5.1 Main Findings

Because the definition of the CIs is now based on seemingly arbitrary industrial lines, the current study aimed to find a process that could characterize the CIs and help with the development of policy by linking job functions to this process. Policy regarding the CIs is now mainly focused on maintaining existing structures that would be difficult to uphold without subsidies or other kinds of incentives from governmental structures (Jones et al., 2015). However, to improve the economy by optimizing the innovative force of the CIs a different kind of policy is needed. That is why we developed a process to delineate the CIs in a manner that is more dynamic in comparison

to frameworks currently used. This dynamic property is important, since the industries for which policy has to be written are more dynamic than structures in the past. Also, work has changed a lot in the last few decades, which has greatly impacted the required human capital. By linking job functions to the work process, it can help in understanding what skills employees need to innovate. This, in turn, can help in writing policy to optimize the innovative power of the CIs. With respect to the first question (what work process characterizes creation and production in the creative industries?), we derived a six-step process: problem analysis, concept generation, provisional design, final design, production/execution, and product introduction (Fig. 1). This process partly overlaps the generation and implementation of ideas (Caniëls et al., 2014), but adds the characterization of a method for collective development instead of focusing on individual creation. The proposed process model is unique in a way that it is meant to be applicable to the CIs as an economy that uses their products as commodities to create value. This has been described as imperative for the CIs (Nesta, 2006; Rutten et al., 2010; UNCTAD, 2008; Yue, 2006). One element that makes this process specifically suitable for the CIs is the role of the problem analysis phase. In the CIs, when this phase is successfully executed, the goal (i.e. what to achieve with the solution) is clear, but the way to achieve the goal (i.e. the solution) is not. Therefore, to achieve the goal, the solution must be both novel – since it is not yet known – and useful. This is in line with the definition of creativity as given by Amabile et al. (1996).

Two components distinguish this process from processes in other industries. Firstly, iterations are an indispensable aspect of work in the CIs. These iterations serve as a check, to prevent a mismatch between the question asked and the final solution being given. In other industries a funnel-like approach to product development is more common, in which taking a step back is difficult. Secondly, the CIs are not just demand-driven. Many products are developed when a person or organization sees an opportunity in the market or in society. Both demand and opportunity are depicted in the work process (Fig. 1).

To follow up on the process model, we attempted to answer the question of what job functions are needed to successfully support this process. We found that, regarding the creative process, a distinction can be made between "core creative job functions" and supporting and executive job functions, which are generally considered less creative. These "non-creative job functions", however, are very important. By connecting all these job functions to the model, we make a case for our approach by acknowledging that it is not only those job functions that are creative at their core that are needed for the creation of economic value in the CIs. Supporting roles such as those of project managers help to complete the process fluently and enable the core creative professionals to work to the best of their ability. This central role of creative job functions is shown in Table 3. Job functions included in the framework of creative job functions in the Netherlands by Urlings and Braams (2011) are mostly prominent in the designer sub-group, which plays the largest role in the beginning of the process. This is where creativity can flow the most freely. The absence of the other job functions in the framework of Urlings and Braams (2011) shows that our process has the unique ability to include all job functions needed in the CIs and is therefore more suitable to use when writing policy for this sector. By using the process approach, policies to improve skills of all professionals in the CIs can be developed.

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5.2 Limitations and Future Research

Although we found a model that seems applicable to most—if not all—developmental activities in the CIs, the capacity to differentiate between the CIs and other industries might be improved upon. However, our goal was to develop a model that could be used to help stimulate growth in the CIs by looking at the human capital needed, and it is our belief that this model enables just that. Still, for future research, the model could be improved to make a better distinction between different industries.

The identified model can be used to study and better understand the CIs. It provides input for processes and the important job functions that are required at each stage of the process. Future studies could research the most important skills among workers at each stage of the process.

5.3 Concluding Remarks

We aimed to find a process that could help us identify and understand the most important aspects of the CIs with regard to how goods and services are developed. This was done by means of a series of interviews with key players in the Dutch CIs. In the Netherlands the CIs receive extra resources to make them competitive players in the international market in hopes of stimulating the Dutch economy as a whole. By identifying a process and connecting the most important job functions to that process, the focus can shift from the level of the working individual or an organization as a single entity to how professionals interact within the sector. In many instances, this interaction will be across the borders of an organization. Because it is not just the creative individual but a team of professionals who make the execution and launch of a product successful, the process can be used to approach issues of efficiency and effectiveness on a higher level. As Carnevale and Smith (2013) state, effectivity and efficiency are important elements that determine an organization's ability to improve productivity and stay competitive.

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ISSN 2183-0606
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Appendix A

Division of the creative sector in The Netherlands according to the Ministry of Economic Affairs and the Ministry of Education, Culture and Science

Creation	Material production	Distribution and retail
Arts		
Visual arts and photography	Visual arts and photography	Museums and exposition rooms, exhibitions, art auctions, art lending, galleries
Performing arts: music, dance and theatre	Production of performing arts: music, dance and theatre	Theatres and concert halls, event halls
Recreation centres, organization of cultural events	Reproduction and publisher of CDs and DVDs	CD- and DVD-stores
	Recreation centres, event halls	Recreation centres, cultural events, event halls
Media and entertainment		
Movie: Scenario, scriptwriting and other pre−production	Film production, including supporting activities	Film distribution, cinemas, film theatres and video stores
Same for radio and television	Production of radio- and television programmes	Broadcasting organizations
Writing: novels, poetry, non-fiction	Publishing and book printing	Public libraries, book stores
Journalism	Publishing and printing of newspapers	Public libraries, shops in book, magazines and newspapers
Creative and business services		
Industrial design, fashion design, graphical design	Manufacturing of furniture, clothing, eyeglass frames, cars, etc.	Trade in clothing, glasses, furniture, cars, etc.
Creative ICT: games, new media	Creative ICT: games, new media	Trade in computers and software
Architecture, urban design, landscape architecture	General civil and utility building, project development	Project development, trade in real estate
Advertising	Printing houses	Other advertising services

Note. Underlined text is part of the limited classification of the creative sector, namely creation. Bold text is part of the broad classification: creation, material production, distribution and retail. Adapted from "Creativiteit in kaart gebracht. Mapping document creatieve bedrijvigheid in Nederland" by Ministerie van Economische Zaken and Ministerie van Onderwijs, Cultuur en Wetenschap, 2005, p. 9.

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Appendix B

Codebook for the labelling and analysis of the interviews and drawings

Themes	**Labels**
Creative Industries (CI)	CI: Demarcation
	CI: Culture/Museums
	CI: Definition CI ? personal
	CI: Definition CI ? political
	CI: Financial interests
	CI: Trademarks CI
	CI: Music industry
	CI: What industry does your organization belong to?
	CI: Education
	CI: Output
	CI: Top sector/Human Capital Agenda
	CI: Why does your organization belong to the CI?
Creativity	Creativity: Importance of creativity
	Creativity: Difference between creativity and creation
	Creativity: What is creativity?
Culture	Culture: Cultural education
	Culture: Societal interest
	Culture: Museums
	Culture: What is culture to you?
Job Functions	Functions: C_Not creative
	Functions: C_Creative
	Functions: F_Architect
	Functions: F_Art/creative director
	Functions: F_Business developer
	Functions: F_Senior editor
	Functions: F_Founder
	Functions: F_Job functions in fashion
	Functions: F_Journalist
	Functions: F_Junior functions
	Functions: F_Manager
	Functions: F_Marketing
	Functions: F_Museums
	Functions: F_Music industry
	Functions: F_Designer

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Themes	Labels
	Functions: F_Other architectural firm
	Functions: F_Other gamedesign
	Functions: F_Presenter
	Functions: F_Producer
	Functions: F_Product development
	Functions: F_Programmer
	Functions: F_Projectleader/Management
	Functions: F_Recruiter
	Functions: F_Editorial staff
	Functions: F_Sales
	Functions: F_Strategist
	Functions: KM_Necessary skills
	Functions: KM_Creatieve job functions
	Functions: KM_Extern/Freelance
	Functions: KM_Flexibel deployable
	Functions: KM_Intern/Tenure
	Functions: KM_Internships
	Functions: KM_Team/Cooperation
	Functions: KM_Support
Organisation	Organisation: Data usage
	Organisation: Financial interests
	Organisation: Milestones
	Organisation: Educating
	Organisation: Convictions/Vision
	Organisation: Structure
	Organisation: Changes
	Organisation: Activities interviewee
	Organisation: Activities organisation
Other	Other
Process	Process: DG_Consumer behavior
	Process: DG_Consumer demand
	Process: DG_Market demand
	Process: DG_Client demand
	Process: KM_Competition/Tender
	Process: KM_Concept
	Process: KM_Context
	Process: KM_Creative intensity

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Themes	Labels
	Process: KM_Diverging/Converging
	Process: KM_Innovation
	Process: KM_Iterations
	Process: KM_Trademarks
	Process: KM_Linear
	Process: KM_Motive
	Process: KM_Problemanalysis output
	Process: KM_Working by means of a process
	Process: KM_Differences
	Process: KM_Different ways of thinking
	Process: KM_Vision
	Process: KM_Waterfall method
	Process: MW_Agile/scrum
	Process: MW_Briefing/Meeting
	Process: MW_Content creation and management
	Process: MW_Game design
	Process: MW_Inspirations
	Process: MW_Design process
	Process: MW_Parallel activities
	Process: MW_What is the creative process?
	Process: ST_Assemble (external) team
	Process: ST_(Problem)analysis
	Process: ST_Final design
	Process: ST_Introduction
	Process: ST_Design phases
	Process: ST_Parametrisation
	Process: ST_Presentation
	Process: ST_Prototype/Testing
	Process: ST_Reflection
	Process: ST_Sketching
	Process: ST_Strategy defenition
	Process: ST_Technical design
	Process: ST_Mid-term analysis
	Process: ST_Execution/Production
	Process: ST_Preliminary design
Process Steps (PS)	PS: Step 1
	PS: Step 2

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Themes	Labels
	PS: Step 3
	PS: Step 4
	PS: Step 5
Skills	Skills: Context_Cultural awareness
	Skills: Context_Ethical awareness
	Skills: Context_Flexibility
	Skills: Context_Lifelong learning
	Skills: Context_Self-direction
	Skills: Core_Collaboration
	Skills: Core_Communication
	Skills: Core_Creativity
	Skills: Core_Critical thinking
	Skills: Core_Information management
	Skills: Core_Problem-solving
	Skills: Core_Technical
	Skills: Digital skill
	Skills: General_21st century skills
	Skills: General_Function aspecific
	Skills: General_Function specific
	Skills: I_Analytic ability
	Skills: I_Broadly oriented
	Skills: I_Empathy
	Skills: I_Higher priority
	Skills: I_Initiative
	Skills: I_Lower priority
	Skills: I_Curious
	Skills: I_Broad-minded
	Skills: I_Tenacity
	Skills: I_Business sense
	Skills: Interviewee

ISSN 2183-0606
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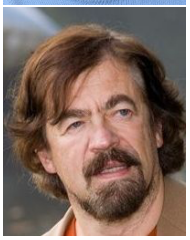

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ISSN 2183-0606
http://www.open-jim.org

Journal of Innovation Management
JIM 7, 3 (2019) 96-122
HANDLE: https://hdl.handle.net/10216/122981
DOI:https://doi.org/10.24840/2183-0606_007.003_0006
SM: Feb/2019 AM: Apr/2019

The Use of Design Thinking in Transdisciplinary Research and Innovation Consortia: Challenges, Enablers and Benefits

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Abstract. The innovation management literature describes a competitive advantage when applying Design Thinking (DT) in corporate environments. In this paper we study the perceived challenges, enablers, and benefits for implementing DT in publicly funded transdisciplinary industry-academia research and innovation consortia (RIC). We facilitate and investigate five large RIC from the food and high-tech industry in Norway and Germany using an explorative qualitative action research design. Our research shows that the challenges of using DT in RIC are to some extent comparable to those for the corporate context. Additionally, we identify distinct challenges for RIC. Benefits from using DT in RIC are stronger user and innovation focus, better transdisciplinary collaboration, and triangulation of qualitative with scientific data. We suggest that complex RIC benefit from an intermediary (DT) role translating business needs into research questions, and research results into understandable and business-relevant information and innovation.

Keywords. Design Thinking; Transdisciplinary; Industry-Academia-Collaboration; Research and Innovation Consortia; Innovation; Implementation; Challenges; Enabler; Action Research.

Cite paper as: Gonera, A., Pabst, R., (2019). The Use of Design Thinking in Transdisciplinary Research and Innovation Consortia: Challenges, Enablers and Benefits, *Journal of Innovation Management*, www.open-jim.org, 7(3), 96-122.

ISSN 2183-0606
http://www.open-jim.org

1 Introduction

Increased competition and a faster innovation pace in a globalized environment motivate participation in research-based innovation collaborations between industry and academia to solve problems none of the stakeholders can solve alone (Sandberg, Pareto, & Arts, 2011). The business model of research organizations however requires public funding, which historically is based on academic excellence only. There is a major change happening: Pure knowledge creation is no longer the aim of many research projects. Funding calls increasingly address complex societal challenges that can only be solved by transdisciplinary teams and in collaboration between industry and academia (European Commission, 2018, Federal Ministry of Education and Research, 2012, UK Government, 2017, Popowitz & Dorgelo, 2018). The recently developed EU mission-based research and innovation strategy addresses global challenges fostering experimentation and citizen involvement (Mazzucato 2018). This is also reflected in several core dimensions of change on how to organize innovation as described by Leitner, Warnke & Rhomberg (2016). Among them is a changing perception of creativity, changing motivation for innovation, and a need for systemic sustainability innovation, which will all strongly affect the way we execute research and innovation projects in the future. These developments seem to legitimize the use of Design Thinking (DT) in the context of publicly funded collaborative research. DT is a human-centered approach to problem-solving, creativity and innovation. DT is also a management concept of innovation that gained massive attention in the corporate world in the recent years and is often referred to as providing a competitive advantage (Liedtka, Salzman, & Azer, 2017, Brown, 2009, Brown & Katz, 2011, Rauth, Carlgren & Elmquist, 2015, Carlgren, Elmquist & Rauth, 2014).

Successful research projects must deliver on social, environmental and economic sustainability through innovation, collaboration, and solving wicked problems. This requires impact-focus and innovation management thinking from scientists and is challenging, as many scientists work to "understand" and not to "create". In the context of RIC, facilitation of transdisciplinarity is needed in order to achieve a working mode where knowing and understanding each other and collaborating to extract the best from every discipline for achieving results beyond what one discipline could achieve alone (Thompson, Owen, Lindsay, Leonard, & Cronin, 2017). Transdisciplinarity in the setting of RIC can be characterized by different features according to Zscheischler, Rogga, & Busse (2017): collaborative problem framing and co-designing the research process, integrating knowledge form different disciplines, and science-practice collaboration.

We observe a mismatch between external funding and industry requirements and the scientists' capability to lead and work in transdisciplinary impact-oriented projects. DT with its focus on user needs, co-creative problem-solving, and innovation outcome could help to bridge that gap when introduced in a way that accounts for both culture-, sector-, topic-, and team-specific factors in the socio-technical system of a RIC (Liedtka et al., 2017). DT has not been widely used in publicly funded research and innovation consortia, and there is a lack of understanding which challenges and benefits its use implies. The aim of this study is two-fold: Describe the facilitated introduction and continuous use of DT in RIC and study the perceived challenges, enablers, and benefits of implementing and using DT in RIC. In our action research-based case

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study, we selected five large RIC from the food and high-tech industry in Norway and Germany where DT was introduced and applied continuously.

2 Theoretical Background

2.1 Design Thinking

DT in an innovation management context can be described as a human-centered approach to problem-solving, creativity and innovation combining what is technologically feasible, with what is desirable and economically viable (Brown, 2008, Brown & Katz, 2011, Verganti, 2008, Beckman & Barry, 2007, Liedtka, 2015, Carlgren, Rauth & Elmquist, 2016b). DT is a meta-disciplinary methodology where pre-established rationales of one discipline are replaced with a mindset that helps to develop a common basis of knowledge and agreement between disciplines (Lindberg et al., 2010). The benefit of DT is still difficult to proof and measure. One of the few measurable successes of design-centric companies that are part of the design value index is that they outperform their peers from the S&P500 by over 200% (Rae, 2016).

The core elements of DT are empathy and people focus, problem framing, visualization, experimentation, and diversity (Carlgren et al., 2016b). They are often paraphrased or visualized by an array of diverging and converging processes of need finding, idea generation, and testing (Liedtka, 2015) in contrast to more traditional product-centric stage gate and linear innovation processes (Cooper, 1990). Different models of operation with a more or less rigid set of tools and methods exist based on their origin and primary use at e.g. IDEO, Hasso Plattner Institute, Darden School of Business, or the British Design Council (Tschimmel, 2012, Carlgren et al. 2016b). The Double Diamond model from the British Design Council is divided in four distinct phases (see Figure 2): The diverging *Discover* phase - gathering new insight by looking at the world from different perspectives. The converging *Define* phase - making sense of the information from the first phase and deciding which opportunity matters most. The diverging *Develop* phase - repeated cycles of creation and testing of concepts and prototypes leading to constant improvement of ideas. The converging *Deliver* phase - validating and implementing the innovative solutions (products, services, technologies, designs, business models).

It should be noted, that DT is not only a toolset but also a mind-set and therefore not easy to implement in settings where linear thinking and hypothesis-based working are the dominant logic (Carlgren, Elmquist & Rauth, 2016; Liedtka et al., 2017). We planned and researched the use of DT in RIC according to the Double Diamond Model and its phases as our project facilitation framework and theoretical lens.

2.2 Design Thinking in the Corporate Context

Brown and Katz (2011) encourage the use of DT and the designer's creative problem-solving skills by non-designers into the broader organization. As stated above, adaptation and use of DT is however challenging when coming from a different school of thought where a technology or product is often developed and put onto the market rather than starting with a user need. While

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designers are comfortable with insecurity and ambiguity, managers and scientists are usually risk averse and afraid of failure.

Several academic studies describe theoretical reflections of conceptualizing DT (Johansson-Sköldberg, Woodilla & Çetinkaya, 2013, Kimbell, 2011), an empirical study by Carlgren et al. (2016) is deliberately distancing itself from that approach by focusing on the use, users, terminologies, and perception of DT in large corporate organizations. Carlgren's study leads to a better understanding of how and why DT is used and proposes a research agenda to better understand the value of using DT, to develop a common language when discussing DT, and to study DT as managerial practice. The authors call for more empirical studies on how DT is used and which value it creates depending on the context it is applied in as well as how DT skills are learned and taught in an organizational/project context.

Seven specific challenges unique for using DT are described by Carlgren, Elmquist & Rauth (2016a) based on empirical data from five large firms (see Figure 1). The challenges are linked to the inherent characteristics of the DT concept itself in relation to its core themes: user focus, framing, experimentation, visualization and diversity (Carlgren et al., 2016b) and distinct from established barriers to innovation. A more structured approach to DT is needed when practicing DT with non-designers, relating to competency development, establishing structures and routines and the facilitation of DT (Liedtka et al., 2017). The study of Rauth et al. (2015) on legitimizing DT in large organizations identifies five ways to create or sustain support for DT (see Figure 1). The challenges to overcome uncertainty around the DT concept that encourages failure and exploration outside the comfort zone were especially large in organizations with traditional R&D structures. This could also be the case in RIC based on their R&D centric nature.

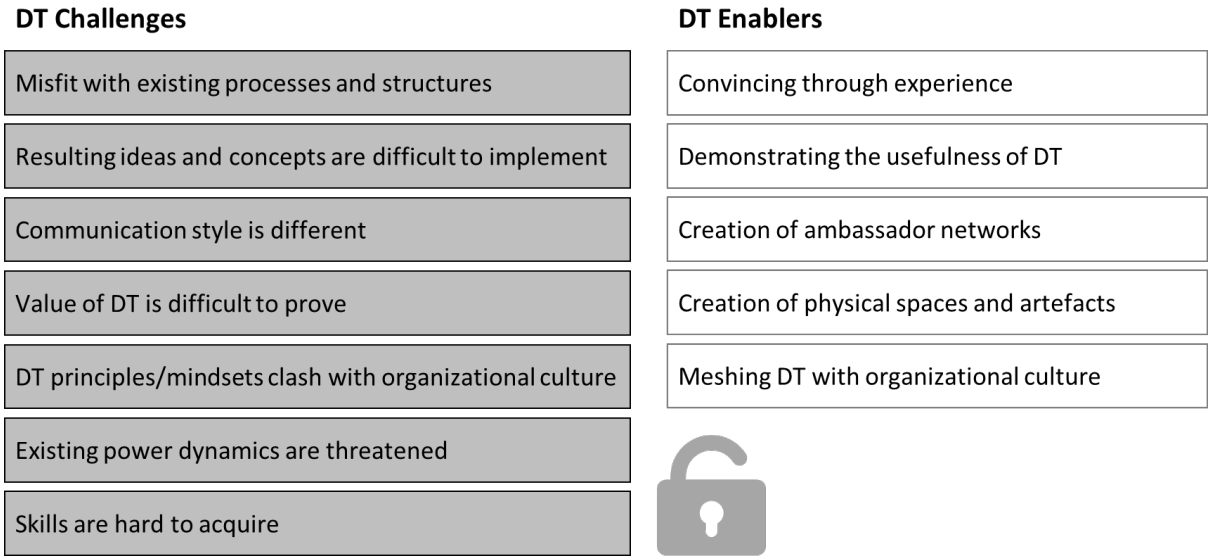

Fig. 1. Challenges and Enablers for using DT in Corporate Context according to (Carlgren et al., 2016a, Rauth et al., 2015, Seidel & Fixson, 2013)

A recent study of 50 industry projects from Liedtka (2018b) describes DT as a paradigm that enables people's full creative energy, commitment, and an improved innovation process. DT

creates a natural flow from early insights to user experiences to the transformation of these insights into ideas and actionable solutions. The DT process overcomes human biases and is able to provide immersion, helps sense-making, builds alignment, and fosters articulation: *"What makes DT a social technology is its ability to counteract the biases of innovators and change the way they engage in innovation processes".* Another study (Liedtka, 2018a) of 22 companies, NGOs, government association (no industry-academia collaboration projects) explores the impact of DT in action and describes the observed practices of deep understanding of user needs, heterogeneity of teams, dialogue-based conversations, multiple solution outcome, creation of a structured and facilitated process. Those practices have shown to lead to improved quality of choices, reduce risk and cost failure, enhance likelihood of successful implementation, increase adaptability, and contribute to capability building. These are practices and outcomes becoming increasingly important also for industry-academia collaborations.

Existing research on DT as method, mindset, and innovation enabler is limited to corporate environments and often restricted to a single company or comparison of a few companies (Carlgren et al., 2016a, Rauth et al., 2015, Wrigley, 2017, Liedtka, 2018b). This underpins a lack of understanding on how DT is practiced in organizations and how DT benefits innovation outcome. Based on literature search, we discovered an even larger research gap on understanding how DT is used in large multi-year science projects with interorganizational and transdisciplinary industry-academia collaboration such as RIC.

2.3 Industry-Academia Research and Innovation Consortia and Design Thinking

The main differences between corporate R&D and academic R&D is the focus on business productivity versus personal productivity and building customer value versus building reputation with peers (Simons, Gupta & Buchanan, 2011). Corporate R&D appears to have goals and motivations similar to DT (user desirability, technical feasibility, commercial viability) whereas academic R&D is more self-centered and focuses on academic merits and peer recognition. The authors suggest that some of the DT motivations and tools could apply to corporate R&D especially by working multidisciplinary, collaborating radically, incentivizing knowledge sharing and change. However, Simons et al. (2011) merely raise questions rather than providing answers on how this potential can be utilized. Due to the different nature of corporate and academic R&D challenges implementing DT into RIC are expected to be different and multifaceted and currently not understood.

RIC become increasingly complex and different communities of practice working to solve a large scientific or innovation challenge are needed. "*Conceptually, transdisciplinarity aims to foster meaningful knowledge co-production through integrative and participatory processes that bring together diverse actors, disciplines, and knowledge bases.*" (Thompson et al., 2017). This concept is not easy to implement as disciplinary success is often higher rewarded in academia and communication between disciplines can be a major challenge (Benard & de Cock-Buning, 2014, Basche et al., 2014). Designers can act as brokers through applying their user centric, socio-cultural and product semantic skills to the creation of new (product) meaning (Verganti 2003) and have the ability to successfully facilitate multi-stakeholder co-creation activities (Aguirre, Agudelo &

Romm, 2017). Alves, Marcques, Saur & Marques (2007) study multidisciplinary and multisectoral cooperation as catalysts for creativity and innovation without explicitly mentioning DT but describing some of the tools and methods. Their study provides a limited view on new product development and does not include long term collaboration projects or RIC. Interestingly, diversity from multidisciplinary and multisectoral collaboration is discussed exclusively as positive for innovation. Emerging management challenges are mentioned only very briefly and remain unspecific.

The expectation to collaborative R&D is moving more towards impact creation (Mazzucato, 2018). However, classical project management in an innovation context has its limitations in a sense that it tries to apply a rigid framework to an agile and unpredictable process (Mahmoud-Jouni, Midler & Silberzahn, 2016). The expected contributions of DT to project management in an innovation context for exploration, stakeholder involvement and strategizing on a theoretical level provide an interesting steppingstone for our work in RIC. Garousi, Petersen & Ozkan (2016) identified 10 challenge themes and 17 best practice themes in their review article on industry-academia collaborations. Most common best practices documented in different contexts are regular workshops and seminars, continuous learning from industry and academic sides, ensuring management engagement, the need for a champion, conducting research based on real-world problems, showing explicit benefits to the industry partner, and agility during the collaboration. Once more the described practices are coherent with a DT-mindset, but DT was not explicitly applied or mentioned. A recent action research study reveals a positive impact of co-production / co-creation activities (as in DT) to joint problem formulation, research methodology, capacity-building, communication, and project outcome in industry-academia collaborations (Sannö, Ericsen Öberg, Flores-Garcia, & Jackson, 2019), however, DT has not been mentioned specifically as facilitation tool.

Many of the studies mentioned above describe shorter activities compared to RIC projects with focus on an innovation solution or are even purely theoretical. Principles of co-creation, agility, transdisciplinarity, industry relevance, and innovation outcome are the focal point of several scholars. According to our literature search, DT has not been used extensively and consistently nor has it been studied in industry-academia collaboration such as RIC to increase transdisciplinary collaboration, user focus/relevance and innovation outcome. Thus, there is a research gap on both the use of DT in RIC and understanding the challenges and benefits this implies. The research question in this paper is: How can DT contribute to better collaboration across disciplines and between theory and practice in complex industry-academia RIC? The aim of this study is therefore two-fold: Firstly, we elucidate how we use DT in RIC to foster transdisciplinarity and innovativeness by describing and analyzing five large RIC (our cases). Secondly, we empirically study the perceived challenges, enablers, and benefits of implementing DT in RIC in the light of existing research. Focus of the research is on the use of DT as facilitation tool to improve transdisciplinary collaboration, user-focus, and innovation outcome in RICs.

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3 Method

3.1 Research Context and Case Descriptions

We studied the use of DT in joint academia-industry research and innovation consortia (RIC) from a pre-project stage throughout the project's duration. We designed and selected the RICs based on the following common criteria in order to assure comparability across cases:

- they are publicly funded based on competitive research proposals, which means similar set-up and KPIs,
- the projects require a high degree of transdisciplinarity, which is challenging to realize in traditionally run RICs
- the DT methodology is new to the project teams, and thus allows us to study the implications of using DT in an exploratory action research setting,
- they have a Design Innovation Catalyst (Wrigley, 2017) also acting as the action researcher assuring robust implementation and execution of DT activities
- the project duration is between four to six years with minimum three years into the project allowing for rich and diverse activities and data collection throughout all phases of the DT process.

We studied three national and two international RIC from the food industry and high-tech industry in Norway and Germany, respectively. Table 1 shows an overview of the five cases in this study.

Table 1. Overview of Research and Innovation Consortia in the Study

Case	Funding	Participants	Description
Plant Protein	EUR 4 mill NRC BIONÆR	22 partners (13 research organizations, 9 food companies) from 5 European countries	Research Project: Develop knowledge platform for optimal production/utilization of Norwegian plant raw materials accelerating adaption and value creation from plant-based protein-rich resources to future food products.
Food Safety	EUR 9 mill EU H2020	32 partners (7 NGOs, 18 research organizations, 3 large enterprises, 4 SMEs) from 14 European countries	Research and Innovation Project: Reducing health burden from foodborne illnesses by changing consumers' behavior through effective and convenient tools and products, communication strategies, education and an inclusive food safety policy.

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Case	Funding	Participants	Description
Food for Elderly	EUR 1.5 mill NRC IPN and industry funding	8 partners (4 food companies, 4 research organizations) from Norway	Innovation Project: New insight and knowledge related to elderly people as basis for the development of innovative products, services, and communication strategies that can motivate and facilitate healthier diet and healthy ageing.
Innofo3D	EUR 0.4 mill in a EUR 45 mill BMBF consortium	90 partners (27 research institutes, 47 SMEs, 16 large enterprises, 3 research networks) from Germany	Innovation Research Project: Applied innovation and communication tools, services, and scientific publications for the innovation consortium "3Dsensation" (transdicsiplinary human-machine-interaction innovation)
Camera Sensor	Subproject in EUR 45 mill BMBF consortium	5 partners (large enterprises, SMEs, research institutions)	Product Development Project in the field of human-machine-interaction for the development of a camera sensor

3.2 Design Thinking Approach and Activities in the RIC Cases

We can distinguish between description-driven, explanatory research and prescription-driven design sciences, with an added value, solution focus, and practical relevance of the latter within management research (Aken, 2004). This encouraged our approach of using DT in a field of otherwise explanatory research domains. Applying DT is learning in action (Liedtka, 2018). Based on the hands-on experiences of using this innovation method in five RIC perpetual new insights about the key enablers and challenges were generated.

Classical RIC operate according to a linear project model with a predefined set of activities, often in silos and with little iteration. The linear activities are reflected in a critical path schedule with milestones and deliverables adapted to the reporting requirements following an annual cycle. The DT approach with its iterative phases is new to RIC. Figure 2 describes the project phases of RIC overlaid with the Double Diamond DT phases. The iterative nature of the DT process is reflected by the circular arrows within and between the diverging and converging DT phases. As RIC depend on public funding, a pre-project application phase 12 to 18 months prior to project start is illustrated.

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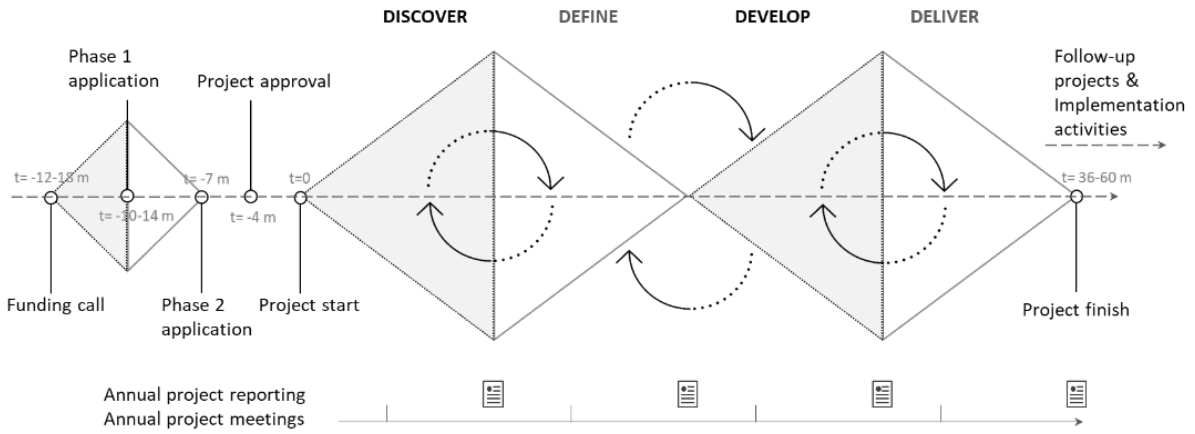

Fig. 2. A typical RIC timeline with project phases overlaid to Double Diamond and DT phases

In the various RIC we used DT as a novel approach to facilitate collaboration and innovation activities, take user-centric perspective, achieve transdisciplinarity, and translate insights into innovations as shown in Table 2.

Table 2. Overview of the use of Design Thinking in Research and Innovation Consortia

Case	Aim of using DT	DT Methods used*
Plant Protein	Achieve transdisciplinarity, Develop innovation strategy, Translate insights into innovations, Work user centric	Future visions, user observation, user survey, prototyping, personas, visualization, co-creation workshops, teambuilding, field trips, iterative testing and validation
Food Safety	Achieve transdisciplinarity, Translate insights into innovations, Work user centric	User observation, user survey, user journey, pains and gains, reflexive DT workshops, opportunity area definition, brain storming, innovation workshops, product design projects, prototypes, visualization, testing and validation
Food for Elderly	Improve project collaboration, Translate insights into innovations, Work user centric	User observation, user survey, personas, pains and gains, user empathy, business ideas, storytelling, prototyping, testing and validation
Innofo3D	Develop innovation strategy, Facilitate transdisciplinary collaboration, Work user centric	Networking, games, roadmaps, personas, user observations, user survey, ideation workshops, storytelling, value proposition design, pitching, prototyping, user testing

Camera Sensor	Facilitate innovation, Facilitate transdisciplinary collaboration Develop new products	Stakeholder analysis, shared vision, persona, storytelling, user journey, value proposition design, pitching, prototyping, user testing

*only main examples, not exhaustive

We deliberately distance our research methodology from the "spectator - astronomer" or "stranger - visitor" paradigm where a researcher observes without intervening (Eikeland, 2006). Transformative knowledge creation can only arise in the context between researchers and practitioners (Bradbury-Huang, 2010) and not as simple observers or through interviews. The large gap between disciplines, and between research and practice in RICs calls for an intermediary role translating research results into understandable and business-relevant information, and business needs into research questions. This role can be described as *Translational Developer* (Norman, 2010) or more relevant for our research the *Design Innovation Catalyst* (Wrigley, 2017, Wrigley, 2016). Wrigley derives six important capabilities of the Design Innovation Catalyst from empirical case studies: designer knowledge and skills, business knowledge and understanding, cognitive abilities, customer and stakeholder centricity, personal qualities, and research knowledge and skills. In line with the DT approach, action research (Guertler, Sick & Kriz, 2019, Guertler, Kriz, McGregor, Bankins & Bucolo, 2017) and engaged scholarship (Van de Ven, 2007) comprise similar benefits of better collaboration, capability building, increased relevance of the research methodology. The research was therefore carried out as action research where the researchers acted as boundary subject, process leader, change agent, and innovation catalyst (Huzzard, Ahlberg & Ekman, 2010, Price, Wrigley & Matthews, 2018, Wrigley, 2016). Our primary purpose was not only understanding how to implement DT in RIC but actively effect the desired changes and empower stakeholders. Our action research and its central elements are designed to solve a research challenge (the RIC's thematic research focus) and thus has the ability to combine an academic knowledge gain with solving a practical problem and capability building (Guertler et al., 2017).

3.2 Data Collection and Analysis

As research on using DT in RIC is scarce, we applied an explorative qualitative research design. This study builds on a multiple case study (Yin, 2017, Eisenhardt, 1989) investigating five RIC from different industries and different countries.

The findings of this study rely on a three-year co-creational knowledge generation process. The data was collected in the period of 2015 to 2018 in the different phases of the case projects. The iterative DT activities and linked learning cycles took place in each of the five RIC and is based on a two-fold knowledge creation process due to the role as Design Innovation Catalyst and action researcher (see Figure 3). We organized and participated in events, workshops, project meetings, and conferences where we observed the behavior of project participants in each of the cases. During and after these events we took detailed field notes and photographic documentation. Additionally, we conducted semi-structured and informal interviews with representatives of our

case organizations and took part in informal reflective conversations. Observations and interviews revolved around the use of DT in the RIC context, how it was perceived, what the benefits and challenges were and how the approach could be improved.

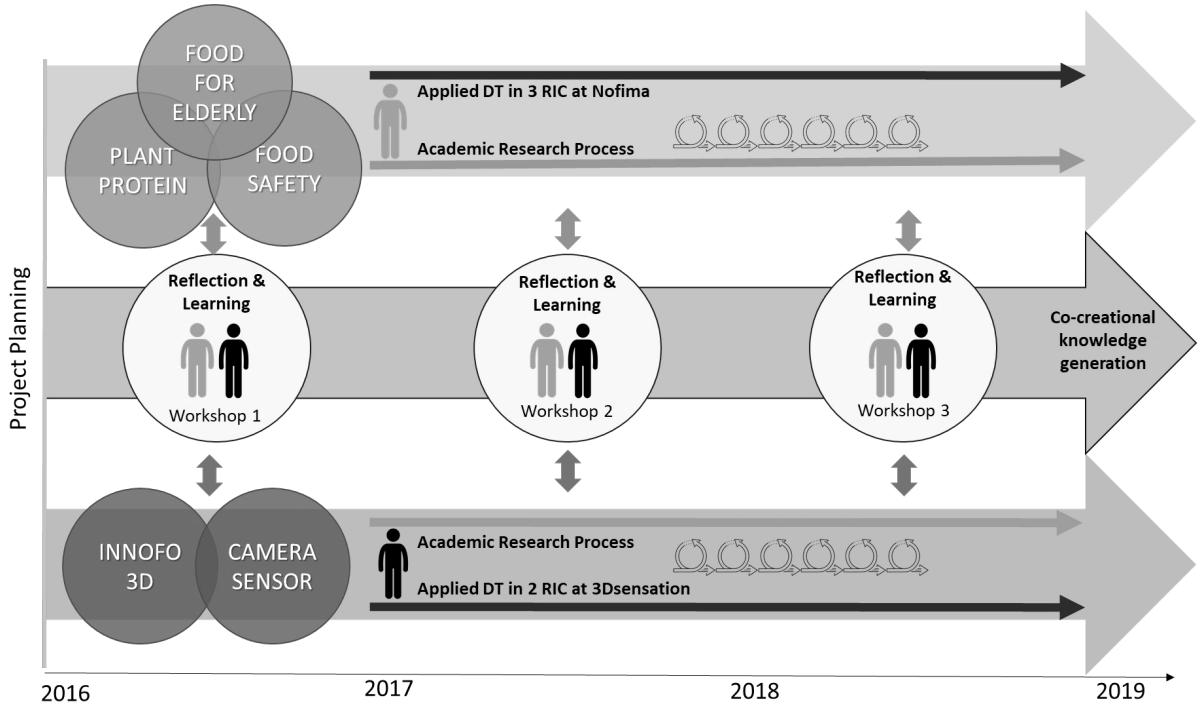

Fig. 3. Illustration of action research approach within and between five cases

We comprehensively collected secondary material describing the broader context of the cases (policy documents, company information, project descriptions, and results from other activities in the RIC). This allowed triangulation of the findings from our interviews and observations, strengthening the quality of our findings (Flick & Gibbs, 2007). Knowledge creation took place by practicing DT at different stages of the research and innovation projects and validating the gained insights. The researchers shared their insights, reflected their learnings, and designed upcoming DT and research activities in three annually held one-day face-to-face workshops and had shorter exchange meetings during the three-year data collection period.

For further exemplification of our advancement and explanation of how we gathered and analyzed the data within each RIC, Table 3 provides an overview of one RIC's project activities and events for the *Innofo3D* case, their link to the respective DT activities and the action research activities performed at each point in time. The iterative character of DT is reflected by a variation in DT process stages depending on the goals of the particular participants or stakeholder goals at the given project phase.

Table 3. Event specific Design Thinking and Research Activities at Innofo3D

N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
1	2016 Annual consortium conference, 80 people of 90 member organizations participated	June 22-23, 2016	DISCOVER: Moderation of several project kick-off sessions: Introduction to DT methodology and benefits of applying it as an innovation process, moderation of network sessions aiming at building trust	5 Video interviews with RIC project owners about DT, in particular: user focus, empathy and challenges of the application of DT as a project-centered innovation method
2	Prototyping workshop, Consortium internal open 2nd call: "Idea-Invention-Innovation (I^3)" program, around 25 people from 17 different organizations attended	September 30, 2016	DEVELOP: Execution of a one-day prototyping DT workshop (Lego or role-play) including a testing phase, 90s elevator pitch explaining the concrete idea for a one-year side research and innovation project program	Analysis of feedback and evaluation forms of 25 participants about how they perceived the prototyping workshop (takeaways, ideas for improvement) An additional observer joined the workshop and filled out an empathy map to gain deeper insights of the workshop participants
3	Panel presentation and discussion	June 28, 2017	DISCOVER: User Journey of scientific research within an academic-industry innovation project aiming for building empathy	Field notes from discussion with RIC members as well as industry experts at the panel session and trade fair booths

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N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
4	3 Business design workshops with one RIC, 3 to 7 persons of the different member organizations of one RIC participated	November until December 2017	DEFINE & DEVELOP: 3 one-day workshops for defining the Point of View (POV) while using the concept of personas as well as the generation of ideas for distinctive application areas and ideas concerning the business model	Analysis of the participants appreciation of mixing DT, e.g. business model canvas within a brainwriting session, validation of the approach via feedback and evaluation forms and informal discussions
5	2017 Annual consortium, conference, around 80 people of 90 member organizations participated	October 23-25, 2017	DELIVER: Execution of a "Human-Machine-Interaction Hackathon" Prototype validation, testing for hypothesis, concept testing (mockups), pitch of solutions	Follow-up of the winning approaches in forthcoming research and innovation projects funded by the consortia, gaining further insights from mentoring of teams that found each other at the hackathon
6	RICs project kick-offs and workshops	2017 until 2018	DISCOVER: Demand of RIC for more user insights, mapping possible alternatives for technologies, DT & google sprint related activities	Researcher moderated at least 5 meetings and workshops including questioning and feedback form evaluations, activities were initiated by the RIC

N	Event Type and Characteristics	Date	Design Thinking Activities	Action Research Activities
7	Consortium board meetings	2017 until 2018	DISCOVER & DEFINE moderation of 5 board meetings by applying DT methods including (presentation of user journeys of the RIC, post-it brainstorming, project mapping etc.)	Researcher focus was to gain insights from the stakeholder perspective of the consortia. The outcome of each session was documented by an assistant and analyzed by the researcher
8	2018 Annual consortium conference, 75 persons from 90 members participated and 60 external academia and industry expert joined for the open second- and third day	September 17-20, 2018	DISCOVER: this year's event included special sessions "spots on dialogue" focusing on the open exchange for collaborative research progress as well as building further trust among the partners of this consortia	Analysis of the feedback and evaluation forms, an additional observer joined the workshop and filled out an empathy map to gain deeper insight of the workshop participants

Analysis was carried out within cases and across cases according to Yin (2017). We chronologically documented all data linked to the respective activity and project phase of the individual cases. The material was sorted into clusters representing the respective DT activities, observations, and interview notes. The derived challenges and enablers for using DT were then clustered and further refined. A case summary of each case was written to complement the aggregated data and enable cross-case comparison. The analysis was iterative and emerging themes were compared with results from previous research on challenges, enablers and benefits of using DT in other contexts. Categories of analysis in our research where for example individual DT workshops, DT methodologies, workshop outputs, and stakeholder groups. Emerging themes and results were discussed between the researchers and third persons within RIC project teams and in three reflection & learning workshops across all cases. The generated knowledge was immediately applied in further project and research activities. One example of generated knowledge from our reflection & learning workshops is the learning that we need to focus thoroughly on DT capability building in order to successfully use the tools and change a researcher's mindset. This

resulted in increased DT training and exposure to DT in the RIC in addition to the already planned activities. Another learning is that the term DT as such can create aversive reactions which made us focus on the actual workshop output and flow much more than the fact that we are doing DT.

4 Results and Discussion

As the use of DT in RIC has not been studied previously, we build our analysis on different streams of literature from management research, action research, and DT and combine it with our own research data to derive specific challenges, enablers and benefits of using DT in RIC. We deliberately do not include classical innovation barriers (Tushman & O'Reilly, 1996, Kanter, 2006, Tidd & Bessant, 2018, Bessant, Öberg & Trifilova, 2014) in our analysis as we want to focus on the DT specific elements.

4.1 Challenges of using DT in RIC

Success of research projects is measured mainly by numerical parameters such as number of publications, number of patents, number of spin offs and schedule fulfilment (Al-Ashaab, Flores, Doultsinou & Magyar, 2011, Langford, Hall, Josty, Matos & Jacobsen, 2006). This leads to a lower motivation to engage in creative and unknown/uncomfortable activities as already suggested by Pink (2011). We experienced that an established linear project process for RIC is contradictory to the principles of DT which require multiple short iterations and testing loops. However, we find that the mismatch of timelines in RIC with their long duration is even larger compared to the corporate context and that the challenge towards implementation of DT is proportionally bigger.

Our analysis shows that some of the identified challenges for using DT in RIC are comparable the those for the corporate context as described by Carlgren et al. (2016a). The specific characteristics for these challenges seen in the new context of RIC are described in Table 4.

Table 4. Types of challenges using DT in RIC compared to previous studies in corporate context

Known DT Challenges	RIC specific Description
Misfit w/existing Processes and Structures (Carlgren, 2016a)	Used to operating in linear project model, large independency and little co-creation.
Design driven vs. Data driven (Price et al., 2018)	Scientists and engineers educated to trust and generate quantitative data, skepticism to qualitative, explorative and visual data.
Resulting Ideas and Concepts difficult to implement (Carlgren, 2016a)	Nature of ideas and concepts often abstract and futuristic outside comfort zone, desire for perfect solutions right away.

Known DT Challenges	RIC specific Description
Value of DT difficult to prove (Carlgren, 2016a)	Not enough time/touchpoints in RIC to prove value of DT, bad experience with post it's
DT Principles/Mindsets clash with org. Culture (Carlgren, 2016a, Price et al., 2018)	Qualitative work, insecurity of the outcome and fun are not seen as serious research.
Existing Power Dynamics are threatened (Carlgren, 2016a)	Tenure and independent work of especially senior scientists less important in DT teams.
Skills are hard to acquire (Carlgren, 2016a)	No exposure to design or DT in scientist's education and bias towards DT.
Communication Style is different (Carlgren, 2016a)	Long texts and proceedings used for communication rather than visuals.
Cognitive Bias (Liedtka, 2015)	Looking for confirmation or invalidation of a set of hypotheses defined early in the research process. Not open for new solutions.

In our research we additionally identified six new challenges of using DT distinct for the context of RIC:

1. Discontinuity of Activities - One specific challenge of using DT in RIC is the discontinuity of activities and often only annual meetings between project members during the long project duration of four to six years. For example, it was difficult to continue working with material, i.e. personas or stories, developed in joint workshops early in the projects because the participants in the follow-up workshop had lost the empathic connection to the situation or we had different participants in the follow-up workshop that did not know the work we did initially. We observed that acquired DT skills are lost when not practiced in between the activities.

2. Lack of Credibility in the Research Field – The designers and DT facilitators in RIC were initially met with skepticism because the field of DT was new and unfamiliar to the participants. We observed a lack of credibility and trust especially for coaches and facilitators that did not have an education in one of the scientific fields of the RIC as illustrated by the following quote: *"They don't understand what our research is all about"* – scientist. Another explanation for the skepticism were negative previous experiences with creative techniques resulting in statements like *"I have been part of such (DT) processes internally but have usually never heard about it afterwards"* – product developer; *"I am allergic to post its – this doesn't lead to anything and I can spend my time better in the lab"* – researcher.

3. Tension between Intrinsic and Extrinsic Motivation – This may be one of the most fundamental challenges in academia-industry RIC going back to what Simons et al. describe as goals and motivations in R&D (Simons, 2011). The intrinsic motivation of researchers are knowledge generation and peer recognition. We heard statements like "*I just want to get my results published, that's how I am measured*" – researcher; or "*We cannot work like that because it is not publishable*" – scientist. Scientific publications are important for obtaining project funding and thus cannot be ignored as output measures. Industry participants of RIC often underestimate

the need for extensive data collection and want to jump to a solution rather quickly as indicated by statements like "*When can we use the results to make a new product?*" – industry R&D manager. We experienced this tension being a barrier to using DT in early project phases but once established as mindset, DT was able to lower the tension by creating a common understanding of desired scientific and innovation outputs.

4. Extreme Diversity - RIC have an extreme variety of cultural differences as the members often come from multiple countries, organizations, sectors, and disciplines. Compared to the corporate context these transdisciplinary teams make it difficult to find a common language and even more difficult when bringing in the designer's unfamiliar mindset, language, and tools in addition. An illustrating example is the combination of microbiology, social science, educational science, policy, innovation management and design thinking in the *FoodSafety* case: in the early project phase a dictionary between disciplines had to be generated and a common language established to overcome this challenge. A statement by a researcher is *"I don't understand your* [the social scientist's] *way of working and terminologies, you make it so complicated and large",* and vice versa about the microbiologist *"Things are much more complicated than what lab tests and numbers can tell, we need to do it our way".*

5. Lack of "Bias for Action" – Science-driven and theory-driven linear thinking fosters data creation and often statistical proof instead of rapid prototyping and frequent testing with users. In all our cases we observed that it was difficult to engage in spontaneous or guided creative activities or activities involving users due to the fear of a) doing something wrong and b) doubting the value of the activity. One work stream leader stated after a persona and innovation workshop in the "Develop" phase of the *PlantProtein* RIC that *"It is so difficult to come up with things within such a short time, but I am getting used to it as we are using approaches like that in our project more often now. During my first experience I was totally lost".* The bias for action and interest to try a different way of working was higher for younger, less established team members compared to senior scientists.

6. "Team by Law" - RIC teams are selected in each participating organization separately based on expertise in the field and availability without considering creativity/DT skills. Participation is often inconsistent over time and therefore it is difficult to fully embrace DT. RIC participants may have competing market interests which according to our observations leads to skepticism and closedness. This changed over time due to diverging or converging nature of the DT phase (Pabst, Drescher, Haendschke, Tyrasa & Gonera, 2018) and statements around openness and the wish to collaborate after DT workshops became common in diverging phases; "*We can be so proud of us. This was so good. What a feeling"* – project manager and *"I look forward to continued collaboration with you in the project"* – industry partner.

4.2 Enablers for using DT in RIC

The context and ecosystem in RIC are more complex compared to corporate environments due the extreme diversity described above, thus asking for a different practical approach to introduce DT. In the process of facilitating and studying DT in the five cases we derived and developed

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enabling approaches particularly important for the RIC context. These build somewhat on existing literature but differ from previously described enablers.

1. Experiential Learning – We used a "learning by doing" approach to implement DT to RIC as also described in other contexts (Price et al., 2018, Beckman & Barry, 2007, Rauth et al., 2015, Liedtka, 2018). Especially in early project phases it was crucial to have short DT lessons combined with practical workshops on the research topic of the RIC. Examples of these activities are building a joint project vision and roadmap, working with personas, user empathy exercises, and field trips. DT with its hands-on, co-creative methods contributed to the positive experience and fun in joint activities as indicated by the following quotes: *"This was the best session of the entire two days of the project meeting"* – researcher*; "This was fun, and I learned a lot"* – product developer. This again improves team building and collaboration across disciplinary boundaries. Keeping up the continuity of activities showed to be essential for the learning journey. DT is a methodology that leads to trust building, partnership and engagement in teams enabling a better innovation outcome (Liedtka, 2017). We observed that DT contributed to better collaboration in diverging project phases also between RIC participants that have competing interests: " *This time* (with DT) *we really experience the project as a joint project."* – industry R&D manager.

2. Change Agent / Design Innovation Catalyst – A process responsible who is actively driving DT engagement as also described by Price et al. (2018) is a key enabler of DT not only in corporate context but also in RIC. We found that this Design Innovation Catalyst (DIC) needs to have high credibility in the research field to be accepted and successful. The role of the change agent is to translate and facilitate design observation, insights, meaning, and strategy into all facets of the RIC. The role of the DIC is described by project members as *"uniting the language of the technology and the language of the user in the sense of a bridge builder" and to "facilitate and activate creativity and novel thinking and also generate a sense of [. . .] user needs".* In classical RIC this role is basically non-existent, and we are pioneering the approach by our research.

3. Gatekeeper / Advocate for DT – Especially during the pre-project phase, when the overall project approach is designed and in the early (discover) phase of the RIC, a strong advocate for DT was essential to enable the approach (Price et al., 2018). For all cases this was the responsible RIC project manager who acknowledged the potential benefits of using DT in this new context, trusted the DT facilitators in their capabilities, and communicated the importance of working according to DT principles. The role of DT advocate gradually developed into an ambassador network (Rauth et al., 2015) with increasing establishment and success of using DT. Project members started to talk positive about the DT activities to peers and leadership.

4. Established Set of DT Tools and Formats – We developed tailor-made methods in each of the RIC depending on the DT phase and respective challenges we worked on. Explanation of the process and coaching of DT proved especially important to create confidence and trust that the method will bring the team to the desired outcome. The establishment of a DT terminology in conjunction with other fields of the RIC as well the repetition of tools and terminology in a language that is understandable were important enablers. Visualization of the content and summarizing results in a tangible format supported the interest and engagement for DT. We found it particularly important to take research data into account and triangulate it to DT outcomes to improve credibility of DT and minimize the perceived risk when using qualitative methods.

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Adapted DT tools and methods will increase the chance for reapplication and recognition of the methodology in the scientific community.

5. Team Reflexivity - Surprisingly we found that team reflexivity became more important for team performance and using DT in later DT phases. This is in contrast with a previous study by Seidel and Fixson (2013) who find team reflexivity important for novice DT teams especially in the early DT phases. One explanation could be that RIC participants first needed to get familiar with DT and the RIC team before they could develop team reflexivity from initial skepticism.

4.3 Benefits and Practitioner Implications for Research and Innovation Consortia

Successful innovation projects must deliver three things: superior solutions, lower risks and costs of change, and employee-buy in (Liedtka, 2018). Applying DT in RIC has the potential to encounter all of these outcomes. The benefits of using DT in our five RIC cases center around the key DT elements of empathy, visualization, and experimentation for superior solutions. Particularly the use of DT in the RIC funding application phase lead to an overall people-centric approach taking user needs into account and strongly focusing on innovation and (business) impact. We argue that this is a distinct quality and a novel unconventional approach compared to other research projects or consortia and can be further explored and exploited. One researcher summarized his experience after several DT workshops in *PlantProtein* RIC in the following way: "*I have never seen something like that, and I joined a lot of similar huge projects. This is just great and should be a role model for other projects. Others have to learn from what we are doing".*

Scientific RIC have the advantage that resilient studies and knowledge of the field are available already at the project proposal stage/early in the project thus strengthening the DT approach by enabling triangulation. This leads to a perceived risk reduction (through use of data) at the same time as it leads to improved innovation outcome (through use of creativity).

We believe that the use of DT in RIC leads to increased flexibility for the research and innovation process and outcome but to achieve this flexibility good process management and excellent capabilities of the Design Innovation Catalyst are necessary. Based on our findings, we suggest that complex RIC will benefit from an intermediary (DT) role translating research results into understandable and business-relevant information, and business needs into research questions in analogy to Wrigley's Design Innovation Catalyst (Wrigley, 2017). It is recommended that the DT facilitator works closely with the respective project manager to assure seamless execution but also have an important advocate and door opener.

We experienced in the projects that a more innovative and broader form of research result communication was achieved by using DT. In addition to the classical reports and publications also visualizations, physical prototypes, public events, exhibitions, and films were produced reaching a much broader audience compared to classical research projects. This is again in line with the funding bodies' ambitions for effective dissemination and implementation of research results.

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In the projects were a continuous requested for DT facilitation occurred, project participants fully emerged into the DT mindset and developed employee buy-in: "*I was totally surprised by the power of testing prototypes and the willingness of giving feedback by users, thus I find myself questioning much more often.*" - research participant in one RIC.

The introduction and use of DT in RIC must be planned carefully considering the identified challenges. DT must be explained and demystified for scientists and practitioners who are not used to working user-centric, visual, co-creative and iterative so that it can become a respected way of working. Using DT requires sufficient time and resources, especially when the approach is new to the team. This calls for additional project budget with no direct scientific output and may therefore be difficult to justify.

4.4 Implications for Policy Makers

Several of the challenges of using DT in RIC are related to policy framework conditions. Public funding and reporting requirements determine which societal problems need to be solved, who receives funding, and how RIC success is measured. We must work with policy makers and educators to encourage and legitimize DT in RIC. For a successful implementation of DT in publicly funded RIC a change of KPIs for research projects is necessary shifting focus from only scientific contribution to real positive impact on people, planet, profit as also mentioned by Fisk (2010).

At the same time, a development from linear project organization and project reporting to a more dynamic and flexible form should be encouraged by the funding bodies. DT with its phases and elements could enable such a transition. The European Commission's "Implementing an Action Plan for Design Driven Innovation" (European Commission, 2013) aims to understand the impact of design on innovation and strengthen industry competitiveness through design-driven innovation. We observe the onset of that shift in public funding calls and at proposal phase where novel approaches (such as DT) are specifically encouraged, however during project reporting the paradigm shift has yet to happen.

An inclusion of DT skills, creative methods, and innovation studies in the education of scientists of various backgrounds is politically supported (European Commission, 2013). These ambitions have the potential to improve problem-solving skills, collaboration and innovation skills among scientists without compromising on the credibility of science.

5 Conclusion

This paper describes how we use DT in RIC in a systematic and continuous way and makes several contributions related to the potential role of DT as an approach to working in RIC. We identified unique empirically categorized challenges and enablers for using DT in joint academia – industry RIC.

The use of DT was challenging when first introduced to RIC as DT principles are contradictory to scientist's way of thinking and working. Through rigorously applying DT, using Design

Innovation Catalysts, adapting DT methods to the individual cases, and reflecting with the team on the use of DT in RIC we experienced true game-changer potential. There are several challenges to overcome to fully utilize DT's potential in RIC, some of them inherent to the way academia is performing R&D and some of them dependent on policy framework conditions. We suggest that complex RIC benefit from an intermediary (DT) role translating business needs into research questions, and research results into understandable and business-relevant information and innovation.

6 Limitations and Further Research

The results of the study are derived from five cases. The data collected strongly depends on the choice of cases and the persons and material included. In this study, the researchers themselves are action researchers facilitating the DT process at the same time as they perform the research. This means that we are not simply external observers but take a transformative orientation to knowledge creation that can only arise in the context of practice (Bradbury-Huang, 2010). This mode of research provides valuable first-hand insights and experiences enabling an immersive and holistic way of collecting data. We have incorporated learnings from our analysis into the projects immediately and thus achieve a better implementation of DT in RIC.

Methodologically, action research can bear the risk for limited precision in interventions including suboptimal research design as highlighted by the discussion of relevance and rigor in action research (Guertler et al., 2019). Within innovation projects that tackle real world problems, it is easy to rather focus on the problem to be solved than on the research or methodological perspective. Therefore, we emphasize action researchers for a strong self-awareness concerning proper research design and process advancement. Careful planning of the DT activities as well as the linked research is necessary. This was achieved by thorough project design of both the activities and data collection, frequent data analysis and reflection within each case and jointly across cases during the three-year timeline of the study. Shortening learning cycles, increasing the researchers' resources and focusing on an even stronger visualization for a more efficient reflection among research collaborators are some of our learning points.

We study all phases of the DT process and the methods/tools feasible to solve the respective innovation challenge of the case RIC. Not all case projects are completed at the point of analysis but have had at least three to four years of DT experience. Due to the explorative character of the study the results should be considered a "working hypothesis" (Guba & Lincoln, 1994). Our action research approach with its reflective nature as well as frequent validation and feedback with RIC project members lead to a pragmatic validity of the research results and we believe that our data is representative for an exploratory study in an area where cases and data are scarce.

The studied sample is not large enough to analyze for country or sector specific challenges. Based on our empirically derived data further research is needed to investigate in depth understanding of other cases and confirm our hypotheses. A quantitative study within the described cases and beyond could help to validate our findings. Further research is needed to understand specific aspects unique to RIC for example the role of the DT facilitator or the specific combination of

disciplines in a project. As future research we highly encourage to study the use of specific DT tools and approaches in a context and project specific setting. As increased transdisciplinarity was only one aspect emerging as a benefit of using DT in RIC, future research should focus on better understanding the impact of DT on transdiciplinarity. As we found the pre-project phase and project set-up/start-up phases critical for defining common project goals, a common language across disciplines, and aligned on DT as way of working, more focus should be laid on DT stage-specific emerging patterns in RIC in future research. It would also be of interest to compare projects with and without DT as a pure case study (without the action research approach) specifically focusing on transdisciplinary collaboration, capability building and innovation outcome.

Further research studying innovation policy development concerning the use of DT in RIC could provide valuable insights leading to an increased implementation of DT into research-based innovation. This will also shed light on how the fundamental question of adapting incentives and measures for research and innovation projects may be addressed in future.

Acknowledgements

We thank the Norwegian Fund for Research Fees for Agricultural Products (FFL) supporting the study through the project "InnoFood" (NRC262303), the Norwegian Research Council for financial support of the projects "MATLYST" (NRC269077) and "FoodProFuture" (NRC267858), the European Commission for support of the project "SafeConsumE" (GA727580), and the German Federal Ministry of Education and Research (BMBF) with - Entrepreneurial Regions and their initiative "Twenty20" for the support of the research and innovation consortia "3Dsensation" including the "camera sensor" and "InnoFo3D"project.

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ISSN 2183-0606
http://www.open-jim.org

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ISSN 2183-0606
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