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COLLABORATION AND STAKEHOLDER MANAGEMENT: EXPLORING THEIR RELATIONSHIP IN INDUSTRY 4.0 PROJECTS

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Dissertation presented to the Postgraduate Program on Project Management of Universidade Nove de Julho – UNINOVE, as a partial requirement for obtaining a master´s degree in administration.

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“We keep moving forward - opening up new doors and doing new things - because we are curious. And curiosity keeps leading us down new paths.” (Walt Disney)

DEDICATION

I dedicate this research to my family. My son Pedro, my husband Fernando, my parents Lalinha e José Ary, and my brothers Ary e Felipe that supported me before and during this journey.

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ABSTRACT

Industry 4.0 is a powerful wave transforming companies across the globe, in which breakthrough technology enables vertical and horizontal integration of organizations. From strategic to human level, industry 4.0 projects intersect around collaboration, to amalgamate knowledge and interests of a variety of stakeholders. This study aims to propose a research model that explores the connection between collaboration and stakeholder management in industry 4.0 projects. Through qualitative approach, eleven in-depth interviews investigate industry 4.0 projects. Prior to that, two Systematic Literature Reviews (SLR) showed lack of studies regarding collaboration among project stakeholders in smart manufactures. Besides, SLRs provided theoretical background for a preliminary research model. As its main academic contribution, this research characterizes the relationship between collaboration and stakeholder management in industry 4.0 project by eight factors: definition of shared goals, joint problem solving, information exchange, trust relationships, top management support, end-users' centrality, learning mindset and log-term relationships. More mature industry 4.0 projects show information being produced based on data and offered as a service for manufacturing costumers. On the other hand, as a contribution to practitioners, it was identified some manufactures have chosen to organize a Central 4.0 Team, that act as a strategic innovation and collaboration hub, with functions that resemble a Project Management Offices (PMO). As any research project, limitations accompany this study, given only one round of in-depth interviews were performed, they have allowed small room for cross questioning. As opportunities for future research, it was identified servitization business model are typical industry 4.0 projects which potentially render business optimization. Thus, future research could concentrate on deepening knowledge about them, for example, to understand which are their main barriers and what are the antecedents for successful implementation. Besides, how end-users' and eventual interorganizational partners are involved with project decisions.

Keywords: Project management; Capabilities; Industry 4.0; Collaboration; Stakeholders.

RESUMO

A indústria 4.0 é uma onda poderosa que transforma empresas em todo o mundo, na qual tecnologias inovadoras permitem a integração vertical e horizontal das organizações. Do nível estratégico ao humano, os projetos da indústria 4.0 se intersectam em torno da colaboração, para amalgamar conhecimentos e interesses de vários *stakeholders*. Este estudo tem como objetivo propor um modelo de pesquisa que explore a relação entre colaboração e gestão de stakeholders em projetos da indústria 4.0. Por meio de uma abordagem qualitativa, onze entrevistas em profundidade investigam os projetos das manufaturas inteligentes. Antes disso, duas Revisões Sistemáticas da Literatura (RSL) fornecem a base teórica para um modelo preliminar de pesquisa. Como principal contribuição acadêmica, esta pesquisa caracteriza a relação entre colaboração e gerenciamento de stakeholders em projetos de manufatura da indústria 4.0 com oito fatores: definição de objetivos compartilhados, solução conjunta de problemas, troca de informações, relações de confiança, suporte da alta gerência, centralidade no usuário final, oportunidade de aprendizado e relações de longa duração. Projetos mais maduros da indústria 4.0 mostraram informação sendo produzida com base em dados e sendo oferecida como um serviço aos clientes das manufaturas. Por outro lado, como contribuição para a prática, foi identificado que algumas manufaturas organizaram um Time Central 4.0, que atua como *hub* estratégico de inovação e colaboração, com funções que se parecem com algumas dos escritórios de projetos (PMO). Como qualquer projeto de pesquisa, limitações acompanham este estudo, dado que somente uma rodada de entrevistas foi efetuada isto permitiu poucos questionamentos cruzados. Como oportunidade de pesquisas futuras, foi identificado que o modelo de negócio de servitização é projeto da indústria 4.0 típico que potencialmente produz otimização de negócios. Portanto, pesquisas futuras poderiam concentrar em aprofundar os conhecimentos sobre estes projetos, por exemplo, para entender quais são as principais barreiras e quais são os antecedentes para implementação de sucesso. Além disso, para entender como usuários finais e eventuais parceiros interorganizacionais são envolvidos nas decisões do projeto.

Palavras-chave: Gerenciamento de Projetos; Competências; Indústria 4.0; Colaboração; Stakeholders.

LIST OF ABREVIATIONS AND INITIALS

4IR - Fourth Industrial Revolution

AGV - Automated Guided Vehicles

BIM - Building Information Modelling

EPCM - Engineering, Procurement and Construction Management

ICT- Information and Communication Technologies

IPD - Integrated Project Delivery

IoT - Internet of things

PMI - Project Management Institute

PMO - Project Management Office

NPS -Net Promoter Score

RFID - Radio-Frequency Identification

SLR - Systematic Review of Literature

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SUMMARY

COLLABORATION AND STAKEHOLDER MANAGEMENT: EXPLORING THEIR RELATIONSHIP IN INDUSTRY 4.0 PROJECTS

1. INTRODUCTION

Industry 4.0, also named The Fourth Industrial Revolution (4IR), was initiated in 2011 as "*industrie 4.0*". A German strategic initiative to deliver its full power as a long-term program in which technologies, professionals, business models and markets would undergo an evolutionary process (Kagermann et al., 2013). Having long surpassed German borders, industry 4.0 initiatives have been recognized relevant worldwide by The World Economic Forum (2017). In its latest chapter, the World Economic Forum and McKinsey & Company (2019) reported that 4IR leaders have transformed businesses and empowered professionals to capitalize on the full potential of technology. Although, they also announce companies are still unable to achieve the extensive benefits of the transformations at scale.

Development of industry 4.0 may be seen as lead by two forces, pushed by technologies and pulled by transformations in businesses and markets (Lasi et al., 2014). Impelling its implementation, ten types of technologies are commonly referred: 1) big data analytics, 2) simulation of interconnected machines, 3) Internet of Things (IoT), 4) cyber-physical systems, 5) cloud computing, 6) virtual or augmented reality, 7) cyber security, 8) collaborative robots (Moeuf et al., 2018), together with additive manufacturing (de Sousa Jabbour et al., 2018) and artificial intelligence (Kuo & Smith, 2018).

From the business viewpoint, and heaving industry 4.0 momentum, changes in businesses and markets call for shortened innovation lifecycle, customization of products, modularization of processes, sustainable resource efficiency (Lasi et al., 2014), as well as integration of companies' networks (Ferreira et al., 2017; Hasselblatt et al., 2018). Summarizing, Rashid et al. (2018) explain that industry 4.0 smart factories are characterized by machines and systems fully integrated and interoperable, different from the ordinary "islands of scattered automated machines".

Considering business transformations, organizations are expected to develop capabilities and competences to support implementation and operation of industry 4.0. Concepts of capabilities and competences are not new, and could be studied from different paradigms (Le Boterf, 2006; Leonard-Barton, 1992; Prahalad & Hamel, 1990;

Stalk et al., 1992). Nevertheless, they are recognized as building blocks of competitive advantage (Prahalad & Hamel, 1990; Stalk et al., 1992).

While Prahalad and Hamel (1990) identify core competences as the collective learning of an organization, which is hard to imitate and integrates individual technologies and production skills. Stalk et al. (1992) understand capabilities as a set of business processes that are managed to deliver value to customers. Despite not being totally dissimilar, core competences appear to focus on a production expertise, whereas capabilities are broader distributed along the value chain (Stalk et al., 1992). As this study considers industry 4.0 capabilities in a wider sense, exploring how projects are managed, we adopt the definition of capabilities developed by Stalk et al (1992).

Various authors agree that project management is a structural capability for industry 4.0 implementation (de Sousa Jabbour et al., 2018; Holtgrewe, 2014; Rashid et al., 2018). When managing projects, organizations apply knowledge, skills and techniques to create unique products, services or results (PMI, 2017). Besides controlling project scope, time, cost, and risks, key stakeholders are identified targeting their engagement (PMI, 2017).

In the context of industry 4.0 projects, companies align their strategies (Moeuf et al., 2019; Parviainen et al., 2017), to implement collaborative business models (Agostini & Nosellla, 2019; Lerch & Gotsch, 2015; Yun & Liu, 2019). While empowered professionals (Campatelli et al., 2016; de Sousa Jabbour et al., 2018), solve problems collaboratively (Ratzmann et al., 2018; Walker & Lloyd-Walker, 2019).

Thus, from organizational through to individual levels, collaboration among parties emerge as a relevant capability for industry 4.0 implementation. Collaboration may be seen to enclose teamwork and coordination, in the interest of achieving shared outcomes (Bedwell et al., 2012). According to Wood and Gray’s (1991) seminal research, “collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain”.

In industry 4.0, project stakeholders are parties that might collaborate. Individuals and organizations affected by, or that may affect a project (Aaltonen & Kujala, 2016). They are targeted by a more collaborative view of stakeholder management, which recognizes stakeholder’ concerns and interests to draw win-win solutions (Eskerod et al., 2015).

1.1 RESEARCH PROBLEM

Based on the relevance of 4IR transformations, the first challenge of this research was to understand how capabilities and project management had been studied in the context of industry 4.0 manufactures. Attending to it, an SRL, which is detailed on the Research Method (Section 3), was developed to explore these subjects out of 55 articles. Articles were synthesized in six perspectives centered in project management. Five other perspectives – strategic, innovation, human, technological, as well as data management – characterize capabilities in industry 4.0 projects.

On a convergent view, project management supports the implementation of the evolutionary program (de Sousa Jabbour et al., 2018; Hasselblatt et al., 2018; Pejic-Bach et al., 2019). Besides, authors argue innovative, digitalized and collaborative business models may be facilitated by industry 4.0 transformations (Agostini & Nosella, 2019; Lerch & Gotsch, 2015; Parida & Wincent, 2019, 2019; Qu et al., 2019). Likewise, Gartner (2018) recommends manufactures intensify relations between operation and business teams to establish collaborative initiatives.

Processes may be optimized based on integrated and interoperable new technologies (Rashid et al., 2018), which generate large amounts of data to be managed and analyzed (Bernstein et al., 2018; Raptis et al., 2019; Roßmann et al., 2018). However, without multiskilled teams that collaboratively solve problems (Ratzmann et al., 2018; Walker & Lloyd-Walker, 2019), and effective communication with stakeholders (Nikitina & Lapiņa, 2019), implementation of 4IR transformation could be deficient.

According to the SRL, detailed on the Research Method (Section 3), crescent number of articles published yearly shows increasing interest on industry 4.0 capabilities. Despite, project management perspective on these capabilities remains understudied, with only eighteen articles deepening its discussion. For example, while Hasselblatt et al. (2018) state suppliers of IoT projects shall deliver value as an asset to their business partners. Walker and Lloyd-Walker (2019) aim to identify trends shaping the near future of project professionals. Therefore, an empirical study exploring aspects of project management in the context of industry 4.0 would cover this research gap.

Aiming to establish an even narrower focus for the research project, the SRL also identified industry 4.0 projects encompass collaboration among parties. In the context of project management, these parties are project stakeholders. Individuals, groups and organizations that "have a stake" (Freeman, 1984, p. p.24) in the project. Project stakeholder management identifies stakeholders, to plan how to engage them with decisions, while monitoring their adhesion throughout project lifecycle (PMI, 2017).

From macro to micro level, while organizations are stakeholders collaborating to design and implement integrated business networks (Hasselblatt et al., 2018; Lerch & Gotsch, 2015). Individuals are stakeholders collaboratively addressing constraints for project delivery (Sjödin, 2019). Stakeholders collaborate to achieve shared outcomes (Bedwell et al., 2012). Problems are solved together (Rijke et al., 2014), catalyzed by open information exchange and trust relationships (Mollaoglu et al., 2015).

Considering industry 4.0 regards project management as a structural capability (de Sousa Jabbour et al., 2018; Pejic-Bach et al., 2019; Rashid et al., 2018). Industry 4.0 benefits are deepened by digitalized and collaborative business models (Agostini & Nosella, 2019; Garcia-Muiña et al., 2019; Lerch & Gotsch, 2015; Parida & Wincent, 2019; Qu et al., 2019), implemented by multiskilled project teams (Rashid et al., 2018). Also, that no study has researched the relationship between collaboration and stakeholder management in the context of industry 4.0. We elaborate our research question: *How stakeholder management relates to collaboration in industry 4.0 projects?*

1.2 MAIN OBJECTIVE

This study aims to propose a research model that explores the connection between collaboration and stakeholder management in industry 4.0 projects.

1.3 SPECIFIC OBJECTIVES

- Understand how capabilities and project management are portrait in 4IR literature.
- Explore literature about collaboration and project stakeholder management.
- Describe key factors connecting collaboration and stakeholder management in industry 4.0 projects, based on literature.

1.4 REASONS FOR THE RESEARCH

Industry 4.0 has the potential to transform how products are fabricated and value delivered to customers (de Sousa Jabbour et al., 2018). As a long-term evolutionary program, it shall be implemented through projects (Hasselblatt et al., 2018; Kagermann et al., 2013; World Economic Forum & The McKinsey & Company, 2018). More specifically, through collaborative projects (Briones-Peñalver et al., 2019; Lerch & Gotsch, 2015; Ratzmann et al., 2018).

Projects integrate companies across equipment supplying networks (Hasselblatt et al., 2018) and circular economy rings (Parida & Wincent, 2019), involving a variety of companies and individuals as project stakeholders. This requires sharing of design idiosyncrasies, in a context of high uncertainties (Sjödin, 2019). Thus, organizations and individuals intending to collaborate shall share common project goals (Faraj & Sambamurthy, 2006; Gray, 1989; Ratzmann et al., 2018).

In the context of suppliers and customers interaction, Parida and Wincent (2019) alert that co-creation between them could require special attention. They argue collaborative and relationship-based interactions must be favored, from requirement definition to implementation steps. Thus, an empirical study exploring how stakeholder management relates with collaboration in industry 4.0 projects would enrich knowledge about 4IR phenomena.

This study contributes to theory by proposing a research model with key factors connecting collaboration and stakeholder management manufacturing projects in industry 4.0. Besides, it contributes to practitioners presenting good practices industry 4.0 leading manufactures have adopted.

1.5 RESEARCH PROJECT STRUCTURE

This research project comprises seven sections. The introduction is displayed in the first section, to contextualize readers about research subject, propose a research question and define its objectives. Following, the theoretical background is presented in section two, with three subsections: 1) Capabilities and project management in industry 4.0, 2) Collaboration and project stakeholder management, and 3) Key factors connecting collaboration and stakeholder management in industry 4.0 projects.

Research method is described on the third section, comprising two SRLs, as well as eleven in-depth qualitative interviews. Besides, research results and discussions are presented on the fourth section, while conclusions are drawn on the fifth section. Moreover, section six defines contributions for theory and practice, while section seven describes limitations and future research opportunities. Concluding this research project, a list of consulted references is presented.

2 THEORETICAL BACKGROUND

This section exhibits theoretical background supporting the current study. It is structured in three subsections, from wider to narrower paradigm. The first subsection presents literature about capabilities and project management in the context of industry 4.0, from which this study has narrowed its focus. Subsection two deepens on theory about collaboration and project stakeholder management, in broader contexts. Then, subsection three funnels the theoretical background, describing key factor connecting collaboration and stakeholder management in industry 4.0 projects.

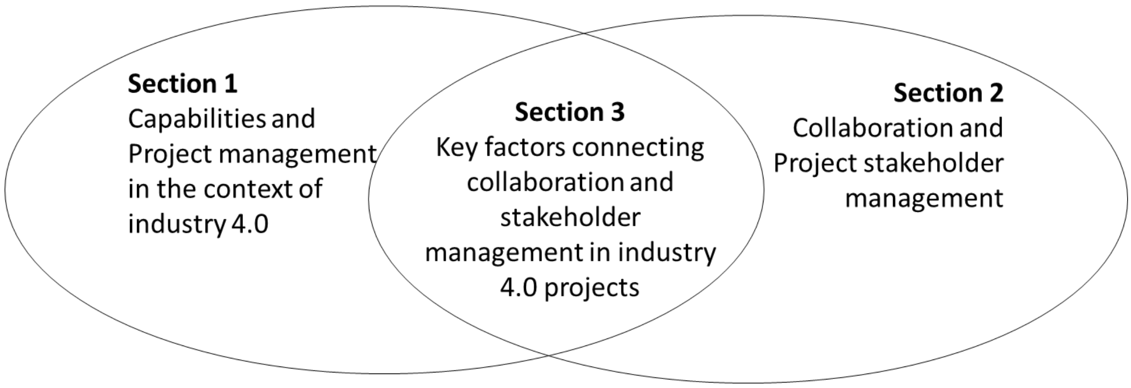

Figure 1: Structure for the theoretical background

Source: Elaborated by the author

2.1 CAPABILITIES AND PROJECT MANAGEMENT IN INDUSTRY 4.0

This subsection is further partitioned, to organize the breath of capabilities researched in industry 4.0 literature, however, previously, industry 4.0 and capabilities are defined. They are followed by a synthesis of each perspective of capabilities researched in industry 4.0 projects: strategic, innovation, human, technological, data analysis and project management.

2.1.1 DEFINITIONS FOR INDUSTRY 4.0 AND CAPABILITIES

As stated, the term industry 4.0 was coined in Germany, defining a strategic government initiative to promote industrial innovation (Kagermann et al., 2013). In specialized literature, it is frequently referred as a synonym for the Fourth Industrial Revolution (4IR) (Caruso, 2018; Schumacher et al., 2016). However, others argue the Fourth Industrial Revolution affects more than manufactures. Schwab (2017, p. 7), for example, states the 4IR is actually "changing the way we live, work and relate to one another", due to the convergence of technology breakthroughs facilitating knowledge access and boosting connectivity between people and machines.

Despite acknowledging Schwab's broader viewpoint, the first phase of this study concentrates on the transformations taking place in manufactures when referring to 4IR. Restricted to the industrial point of view, still many definitions surface. De Sousa Jabbour et al. (2018), for example, characterizes industry 4.0 as a vigorous industrial wave, service-centered and driven by digital technologies.

While Schumacher et al. (2016) explain disruptive technologies allow for horizontal and vertical integration of production and enterprises, which may require different organizational capabilities and strategic developments. With digitalization, companies' borders are surpassed, reaching suppliers and consumers on service-centered and collaborative business models (Ferreira et al., 2017; Hasselblatt et al., 2018; Lerch & Gotsch, 2015).

Therefore, this study's definition of industry 4.0 builds on these concepts. Industry 4.0 comprises business integration implemented with disruptive technologies and obtained by means of data transformation into information and intelligence. It is supported by professionals, teams, and organizations that collaborate to implement industry 4.0 developments.

Integration facilitates interconnection of business processes into core capabilities (Stalk et al., 1992), seen as groups of skills, technical and managerial capabilities (Leonard-Barton, 1992). They promote differentiation and competitive advantage (Leonard-Barton, 1992; Ruas et al., 2004; Stalk et al., 1992). And are supported by functional and individual capabilities (Ruas et al., 2004).

Stalk et al. (1992) also explain that capabilities interweave different organizational functions aiming to serve customers. They group collective skills, knowledge and abilities of organizations, defining what they do well (Smallwood & Ulrich, 2004), surfacing from an assembly of activities (Smallwood & Ulrich, 2004), they are regarded as sources of competitive advantage (Ethiraj et al., 2005).

2.1.2 STRATEGIC CAPABILITIES OF INDUSTRY 4.0 PROJECTS

Manufactures interested on industry 4.0 investments shall first align their strategy, to ensure these investments are structured to be capitalized (Li et al., 2019; Moeuf et al., 2019; Parida & Wincent, 2019; Parviainen et al., 2017; Villalba-Diez et al., 2018). Studying industry 4.0 strategy, Parida and Wincent (2019) argue companies business models may be radically changed when supported by digitalization. Besides, early adopters of digitalization are likely to reach more business value than later comings (Tarifa-Fernández et al., 2019).

In this context, four digitalized business models, implemented through projects, could deepen industry 4.0 benefits and value co-creation. As a common feature, these innovative business models integrate different companies, as well different departments. Servitization (Hasselblatt et al., 2018; Lerch & Gotsch, 2015), sustainable circular economy (Garcia-Muiña et al., 2019; Kuo & Smith, 2018; Parida & Wincent, 2019), collaborative business networks among related companies (Agostini & Nosella, 2019; Bag, 2018; Rejeb et al., 2019; Yun & Liu, 2019), and intracompany information system integration (Qu et al., 2019), will be further detailed.

Servitization consists on offering a combination of a product and a service, named a product-service (Lerch & Gotsch, 2015). These authors explain data from digitalized product-service enables manufactures to 1) foresee potential failures or maintenance requirements, 2) improve product capacity, and 3) improve product-service design to enhance performance. Moreover, servitization data allows direct assessment of customers' needs, which facilitates customization of product-services on offer (Roblek et al., 2016), as well as product sharing among various users (Bressanelli et al., 2018).

When retrofit data is used to improve product-service itself, it promotes end-users' centered innovation that may contribute to market acquisition (Lerch & Gotsch, 2015). However, on a critical view, Parida and Wincent (2019) highlight companies embarking on servitization should develop capabilities to extract its full potential. Among them how to establish and develop network partners, analyze large amounts of data and upgrade towards sustainable co-creation of business value.

Turning to circular economy, Parida and Wincent (2019) argue companies adopting it could reach new competitive advantages. As such, sustainable circular economy encompasses products and processes development aimed at reducing waste generation, while enhancing resource efficiency and reuse (Kristensen & Mosgaard, 2020). In this context, a study reports about improvements to resource efficiency as an industry 4.0 project outcome, which enabled acquisition and analysis of real time production data (Garcia-Muiña et al., 2019).

In a wider sense, industry 4.0 projects may implement collaborative networks to integrate businesses (Agostini & Nosella, 2019). Two types of webs are exemplified: operation networks in which goods are produced collaboratively (Chehbi-Gamoura et al., 2019; Ferreira et al., 2017), and supplying networks in which new equipment and systems are installed by expertise business partners (Hasselblatt et al., 2018; Rashid et al., 2018). Such networks increase companies' geographical coverage, facilitating identification of emergent strategies (Bertoncel, Erenda, Bach, et al., 2018). However, lack of collaboration would prevent full use of data (Chehbi-Gamoura et al., 2019).

Emphasizing companies' internal strengths, industry 4.0 projects may integrate intracompany information systems, aligned to organizational strategy (Qu et al., 2019; Rashid et al., 2018). In this perspective, supply chain management, enterprise resource planning, product lifecycle management and manufacturing execution systems are integrated (Li et al., 2019; Rashid et al., 2018). Summarizing main aspects of strategic capabilities of industry 4.0 projects, Figure 2 is presented.

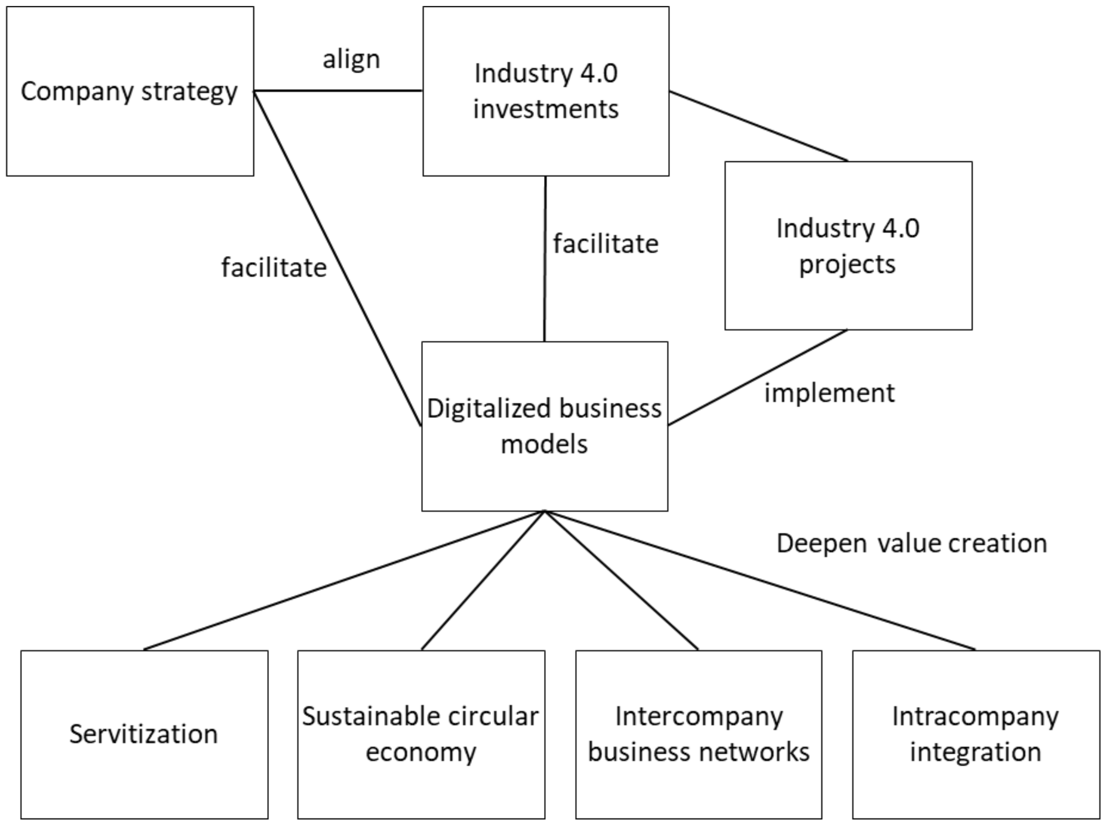

Figure 2: Strategic capabilities of industry 4.0 projects

Source: Elaborated by the author

These digitalized business models improve companies' inner and outer integration. In this context, Agostini and Nosella (2019) found that companies investing in internal and external integration were more likely to implement industry 4.0 innovation. They balance a variety of stakeholders needs, in the company itself or within business alliances, to implement companies' strategic objectives.

2.1.3 INNOVATION CAPABILITIES OF INDUSTRY 4.0 PROJECTS

According to Damanpour (1991), new processes and new technologies are forms of innovation, which generally target better performance. In industry 4.0 manufactures, innovation is also connected to performance (Bertoncel, Erenda, Bach, et al., 2018; Briones-Peñalver et al., 2019; Ooi et al., 2018; Sjödin, 2019), prominently through digitalized business models that favor intracompany (Qu et al., 2019), and business network integration (Lerch & Gotsch, 2015; Yun & Liu, 2019). To supplement their capabilities or better understand market needs, they rely on partners (Briones-Peñalver et al., 2019; Synnes & Welo, 2016), and end-users (Lerch & Gotsch, 2015).

In multidisciplinary industry 4.0 projects, innovation is supported by collaboration. Some studies discuss interorganizational collaboration among manufactures (Bertoncel, Erenda, Bach, et al., 2018; Briones-Peñalver et al., 2019; Lerch & Gotsch, 2015), while others discuss their relationship with other economy sectors (Ho & O'Sullivan, 2017; Yun & Liu, 2019). Yet, others debate intraorganizational dynamics of innovation teams (Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Salehi, 2020; Sjödin, 2019), with the role of manufacturing workers (Campatelli et al., 2016; Hannola et al., 2018; Ratzmann et al., 2018). Following, these three trends will be further discussed.

Studying how manufactures and other economy sectors collaborate, Yun and Liu (2019) highlight industrial firms increasingly adopt open innovation platforms. Facilitated by government, these ecosystems reunite large and small manufactures, universities and customers that share knowledge, needs and commercialize goods (Yun & Liu, 2019). Another aspect of inter sector collaboration debates standards for Information and Communications Technology (ICT) innovation, which would facilitate interoperability across devices (Ho & O'Sullivan, 2017). Adequate standards must consider different perspectives to identify common goals (Ho & O'Sullivan, 2017).

On the other hand, interorganizational collaboration among manufactures facilitate identification of opportunities and implementation of innovative projects. They are seen to improve detection of threats and opportunities (Bertoncel, Erenda, Bach, et al., 2018). Besides, on implementation front, collaboration among manufactures and equipment providers is essential to develop process innovation (Briones-Peñalver et al., 2019; Sjödin, 2019).

Given that industrial processes are interdependent, introduction of new technology often requires further customization (Hasselblatt et al., 2018; Sjödin, 2019). Besides, it is difficult to foresee eventual undesired effects (Sjödin, 2019). Thus, author argues joint problem solving, open communication and early involvement of end-users are instrumental to gather and recombine knowledge into innovation.

Studying intraorganizational dynamics in industry 4.0 innovation teams, authors highlight the power of collective problem solving, when different interpretations challenge and refine ideas (Campatelli et al., 2016; Ratzmann et al., 2018; Salehi, 2020; Sjödin, 2019). Iterative innovation deals with difficulties as they arise (Salehi, 2020; Synnes & Welo, 2016). Feasibility tests (Ratzmann et al., 2018), and process simulation (Synnes & Welo, 2016), for example, contribute to innovation performance, allowing teams to constructively disagree. Besides, trust relationships are seen to improve joint problem solving (Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Sjödin, 2019).

Still on the perspective of team dynamics, when debating the role of production workers in industry 4.0 projects, studies highlight the importance of end-users' involvement and knowledge sharing (Campatelli et al., 2016; Dewa et al., 2018; Hannola et al., 2018; Salehi, 2020; Sjödin, 2019). As senior workers from maintenance and operations have unique understandings about process requirements, they should be early involved in industry 4.0 projects (Sjödin, 2019). On the other hand, industry 4.0 innovation increases opportunities to empower production workers, by facilitating their interaction with other teams and allowing space for self-learning (Hannola et al., 2018).

Knowledge management and learning accompany innovation, from organizational through to individual context (Briones-Peñalver et al., 2019; Hannola et al., 2018; Nikitina & Lapiņa, 2019). While business networks facilitate technology transference among partners (Briones-Peñalver et al., 2019). Industry 4.0 professionals must be curious and committed to continuous learning (Nikitina & Lapiņa, 2019), while sharing knowledge and collaborating, to turn insights into innovation (Nikitina & Lapiņa, 2019). Figure 3 summarizes collaborative perspectives of innovation in industry 4.0 projects.

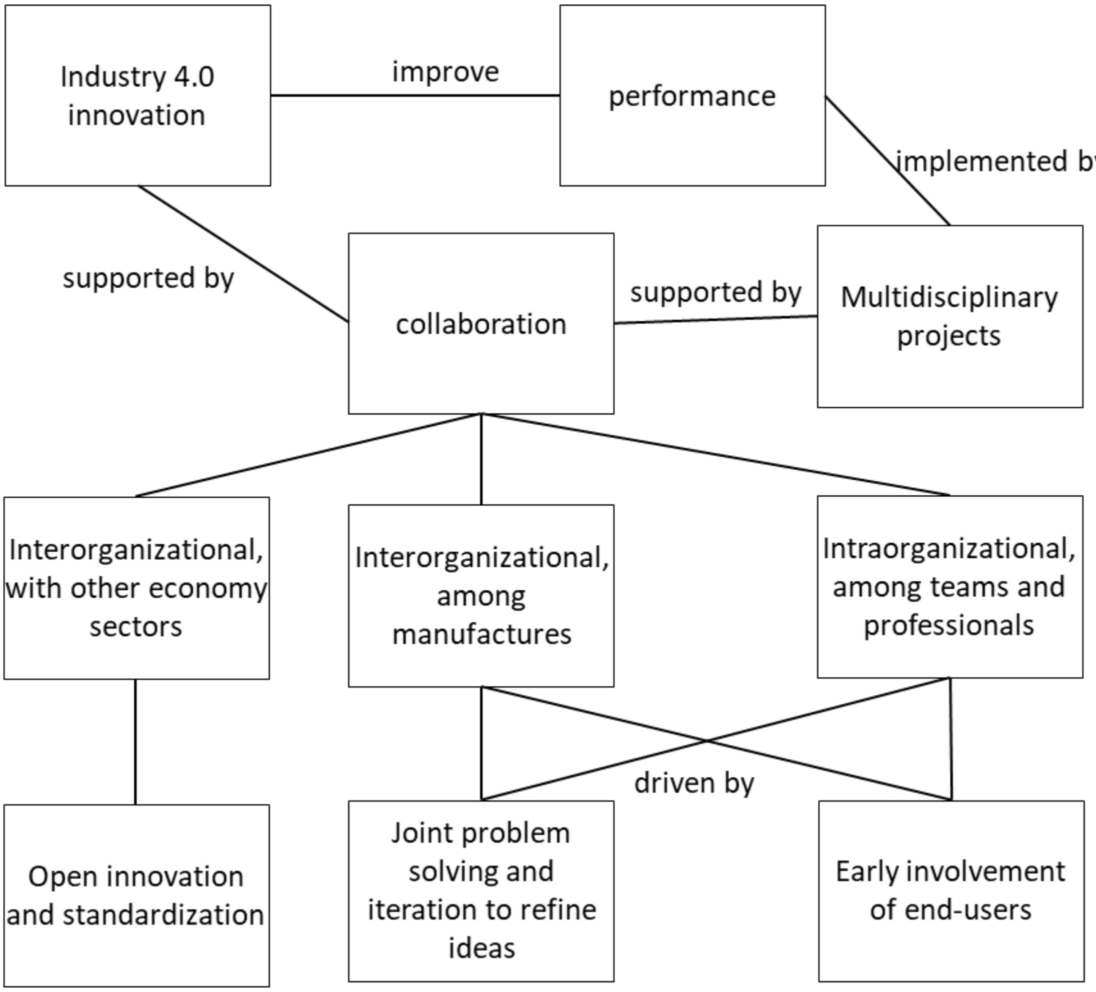

Figure 3: Innovation capabilities of industry 4.0 projects

Source: Elaborated by the author

Industry 4.0 projects improve company performance, supported by collaboration in multidisciplinary projects. These projects might take place among manufactures and other economy sectors, among manufactures in interorganizational partnerships and inside organizations, amid teams and professionals. They are driven by joint problem solving and early involvement of end-users.

2.1.4 HUMAN CAPABILITIES OF INDUSTRY 4.0 PROJECTS

Industry 4.0 projects require professionals that are ICT skilled (Caruso, 2018; Holtgrewe, 2014; Moeuf et al., 2019; Synnes & Welo, 2016), and understand manufacturing business and process (Singh et al., 2019). Additionally, professionals must build relationships and communicate effectively (Caruso, 2018; Hasselblatt et al., 2018). In order to supplement their own capabilities, manufactures rely on consultants, academic and business partners (Li et al., 2019; Moeuf et al., 2019). As such, industry 4.0 projects are developed by multiskilled (Bertoncel & Meško, 2019), cross functional and collaborative project teams (Rashid et al., 2018).

Various authors highlight teamwork as an essential skill for industry 4.0 professionals (Agostini & Nosella, 2019; Bertoncel & Meško, 2019; Holtgrewe, 2014; Nikitina & Lapiņa, 2019; Siddoo et al., 2019). They participate on projects to integrate organizations (Synnes & Welo, 2016), while introducing new technologies to manufacturing processes (Sjödin, 2019). Thus, for effective teamwork, industry 4.0 project professionals shall be able to share knowledge (Nikitina & Lapiņa, 2019; Singh et al., 2019), and collaborate (Bibby & Dehe, 2018; Rashid et al., 2018; Sjödin, 2019; Synnes & Welo, 2016).

Composing project teams, industry 4.0 professionals critically assess problems (Siddoo et al., 2019), with open mind and curiosity (Bibby & Dehe, 2018; Moeuf et al., 2019), to come up with solutions (Agostini & Nosella, 2019; Siddoo et al., 2019). They work together, combining knowledge from manufacturing, business, and IT departments (Agostini & Nosella, 2019), boosted by organizational culture that values continuous improvement (Rashid et al., 2018; Singh et al., 2019), lifelong learning (Siddoo et al., 2019), and business agility (Bibby & Dehe, 2018; Moeuf et al., 2019).

Industry 4.0 project professionals are skilled communicators (de Sousa Jabbour et al., 2018; Hasselblatt et al., 2018; Rashid et al., 2018; Siddoo et al., 2019). They communicate to understand different perspectives (Rashid et al., 2018; Sjödin, 2019), reduce eventual resistance towards industry 4.0 (Li et al., 2019), and to grasp end-users' needs (Campatelli et al., 2016; Hasselblatt et al., 2018). Specifically, end-users' involvement from early stages is claimed to reduce project rework (Singh et al., 2019), while contributing to establish win-win solutions (Hasselblatt et al., 2018). However, this might increase the number of perspectives for a solution (Sjödin, 2019).

Considered industry 4.0 projects rely on intra and interorganizational teams working together, many studies underline the relevance of trust relationships (Agostini & Nosella, 2019; de Sousa Jabbour et al., 2018; Rashid et al., 2018; Roßmann et al., 2018). As they facilitate information exchange (Briones-Peñalver et al., 2019; Ratzmann et al., 2018; Sjödin, 2019), and reduce friction among professionals, steering them towards co-created value (Sjödin, 2019). In the future, experts foresee supply chain management will be as much reliant on data, as on trust relationships, with artificial intelligence supporting human skills (Roßmann et al., 2018).

To improve professional skills, manufactures shall invest on training their professionals (de Sousa Jabbour et al., 2018; Moeuf et al., 2019; Ooi et al., 2018; Singh et al., 2019), and on fostering experimentation (Sjödin, 2019). Despite training establishes a longer path towards industry 4.0 readiness, knowledge integration might be facilitated (Moeuf et al., 2019), and employees resistance might be lowered (Li et al., 2019). Thus, to summarize human capabilities in industry 4.0 projects, Figure 4 is drawn.

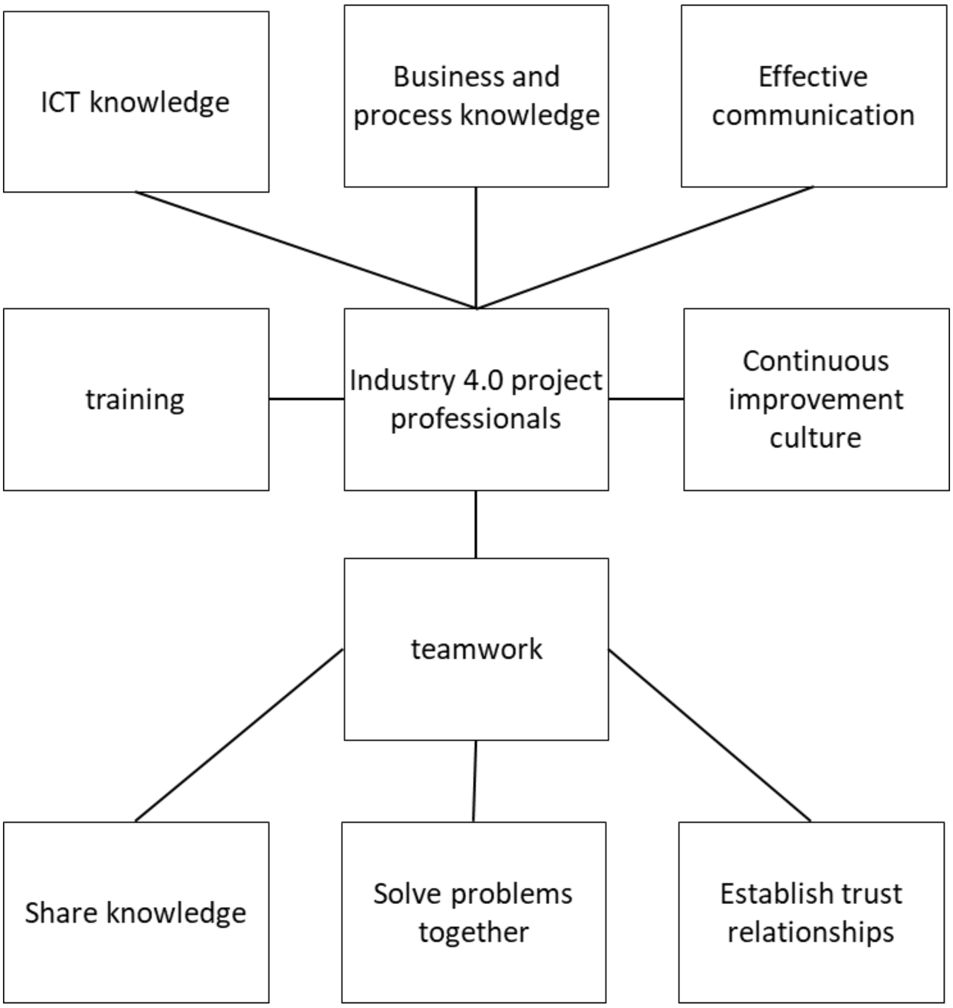

Figure 4: Human capabilities of industry 4.0 projects

Source: Elaborated by the author

Project professionals must navigate the array of technologies supporting industry 4.0 innovation, while understanding business processes and needs. They rely on multidisciplinary teams to supplement their knowledge and experiences. Hence, in this context, it is relevant to establish trust relationships, solve problems together and share knowledge.

2.1.5 TECHNOLOGICAL CAPABILITIES OF INDUSTRY 4.0 PROJECTS

Industry 4.0 projects is implemented by ten new technologies: 1) big data analytics, 2) simulation of interconnected machines, 3) IoT, 4) cyber-physical systems, 5) cloud computing, 6) virtual or augmented reality, 7) cyber security, 8) collaborative robots (Moeuf et al., 2018), 9) additive manufacturing or 3D printing (de Sousa Jabbour et al., 2018) and 10) artificial intelligence (Kuo & Smith, 2018). Following, each technology is briefly discussed.

Big data are data sets continually generated in large amounts, and with different formats (Babiceanu & Seker, 2016). Authors explain data analytics is the process of having these large data sets evaluated to return business value. When experts are consulted about benefits big data may bring to supply chain, in the future, they predict effective data analysis will enhance order forecasts and reduce storage, improving overall supply chain management (Roßmann et al., 2018). However, manufactures considering big data adoption are concerned about perceived benefits, complexity, and integration issues (Yadegaridehkordi et al., 2018).

Internet of Things (IoT) is an information network that connects sensors and physical objects, the so called “things” (Rejeb et al., 2019). Authors exemplify physical objects range from pallets of goods to everyday tools, from consumer objects to household appliances or industrial machines. In the context of supply chain networks, in which products are supplied by intertwined companies, IoT promises performance improvements, while conjugation of blockchain technology and IoT suggests improved data protection (Rejeb et al., 2019).

Cyber-physical systems are composed by collaborating computational units closely connected to physical machines, and surrounded by industrial processes, consuming and providing data to the internet (Monostori et al., 2016). For example, they may be applied to improve machine maintenance plan, by comparing real time with historical data to indicate maintenance requirements (Monostori et al., 2016).

Cloud computing allows access to software applications and data from anywhere in the world, because they are supplied as a service, on demand (Buyya et al., 2009). On the other hand, simulation of interconnected machines enables virtualization of processes, products and systems, which could be employed on scenario validation and optimization (Moeuf et al., 2018). For example, study reports how a simulation model has facilitated scenario evaluation, when reconfiguring an existing manufacturing unit, prior to effective automation (Caggiano & Teti, 2018).

Virtual reality reconstructs real life in a computing scenario, with high-tech elements simulating reality to evaluate changes to manufacturing processes (Jonghwan Lee et al., 2011). For example, research reports virtual reality assists on layout planning (Jonghwan Lee et al., 2011). Cyber security, on the other hand, protects manufacturing companies from cyberattacks that may target digital and interconnected industry 4.0 (Wells et al., 2014). Experts believe threats to supply chain security will continue to exist in the future, even though improvements to security are made, because hackers evolve malicious applications to accompany system evolution (Roßmann et al., 2018).

Collaborative robots are designed to work with humans, improving industrial process while adapting to changes (Djuric et al., 2016). For example, research reports that collaborative robots were employed to automate a deburring unit, replacing production workers on tasks with high injury risk (Caggiano & Teti, 2018). On a different perspective, additive manufacturing allows components and goods to be produced without specialized machines and tools, using 3D printing (Holmström et al., 2016). It facilitates product customization, while allowing large scale prototyping (Holmström et al., 2016).

At last, artificial intelligence consists in having algorithms perform typical human functions, like learning with feedbacks (Ellen MacArthur Foundation & Google, 2019). Authors argue artificial intelligence may boost circular economy businesses, making collaborative data analysis available to business users and providers. Another application involves supporting human decision making, in supply chain management (Roßmann et al., 2018).

These technologies may target applications with different level of maturity in industry 4.0 development. Monitoring, controlling, optimization and autonomy applications (Moeuf et al., 2018; Porter & Heppelmann, 2014), are listed from low to high maturity (Porter & Heppelmann, 2014). Considering this, only monitoring applications were observed on study about industry 4.0 initiatives in Small Manufacturing Enterprises (SME) (Moeuf et al., 2018). Besides, they remain driven to cost reduction, with no innovation directed to business models (Moeuf et al., 2018).

Likewise, Fetterman et al (2018) also reports only monitoring applications, which points to an incipient use of technologies, only for tracking and reporting. Nevertheless, factories are searching for professionals with knowledge and skills in embedded and distributed system development, who could aid them build and improve intelligent machines and devices (Pejic-Bach et al., 2019).

On the road towards automation and integration, some manufacturing tasks are still carried out by skilled operators due to process variability (Goh et al., 2019). However, Rashid et al. (2018) explain smart factories are characterized by machines and systems fully integrated and interoperable, different from the ordinary "islands of scattered automated machines". Thus, manufactures willing to implement industry 4.0, shall be committed to a long-term innovation process (Rashid et al., 2018). Figure 6 summarizes technological capabilities of industry 4.0 projects.

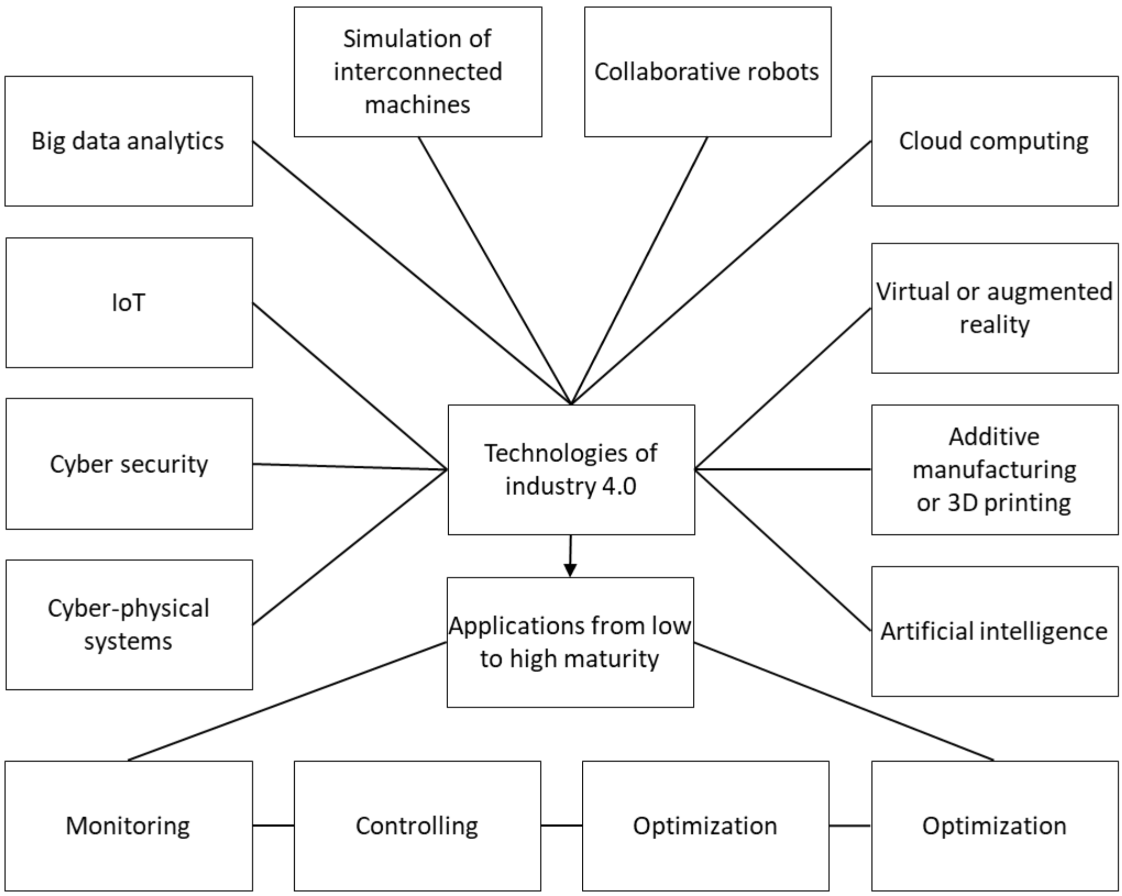

Figure 5: Technological capabilities of industry 4.0 projects

Source: Elaborated by the author

Industry 4.0 projects are supported by a set of technologies to implement monitoring, control, optimization, and autonomy capacities. In this context, technologies and capacities are selected to meet business requirements. To select appropriate technology business shall also consider their current maturity on industry 4.0 projects.

2.1.6 DATA ANALYSIS CAPABILITIES OF INDUSTRY 4.0 PROJECTS

Innovative business models rely on data to foresee potential faults, improve product capacity and retrofit design lifecycle (Hasselblatt et al., 2018; Lerch & Gotsch, 2015). When manufactures equip their products with IoT technology and adequately analyze generated data, collection activities at product end-of-life are improved (Bressanelli et al., 2018). Besides, data availability and quality are reported as prerequisites for successful big data analytics (Roßmann et al., 2018). They leverage overall control of manufacturing processes, bringing companies closer to competitive advantage (Raptis et al., 2019).

Therefore, companies engaging on digitalized business models must be equipped to acquire and direct industrial data towards a repository where information will be analyzed (Raptis et al., 2019). Timely, large amounts of data are generated by intelligent machines, systems and sensors (Raptis et al., 2019; Wang et al., 2018). Since business main intention is targeted at extracting value from such data (Moeuf et al., 2019; Raptis et al., 2019), industry 4.0 projects must target analysis of industrial data (Li et al., 2019; Wang et al., 2018), which is improved when data timely supports managerial decisions (Olszak & Mach-Król, 2018).

Data standardization is key on the road to integrate heterogeneous systems (Bernstein et al., 2018; Ho & O'Sullivan, 2017; Wang et al., 2018). Bernstein et al. (2018) report how information generated by production and maintenance systems were used to retrofit product lifecycle. However, data from different subsystems had to be manually matched, because system parameters were not standardized (Bernstein et al., 2018). Thus, benefits will be leveraged when data standardization is improved (Bernstein et al., 2018).

On a more technical perspective, Raptis et al. (2019) state industrial data is typically stored in centralized cloud networks. They alert this approach may present risks regarding data ownership and cloud network capacity. Hence, to mitigate such risks, it is suggested manufactures employ a combination of local and global networks, to constitute a multi-layered cloud infrastructure (Raptis et al., 2019). However, authors defend data related to recent events must remain available locally, to dispense transferring them back and forth among local devices and global cloud networks.

When addressing data visualization, graphic panels could assist on performance indicators monitoring, facilitating data control and analysis (Gunckel et al., 2018). In this context, graphic visualization (Gunckel et al., 2018), and digitization of real time data (Shivajee et al., 2019), facilitate information reading, supporting decision-making, fault detection, as well as identification of improvement opportunities.

Regarding data security, there are still developments to be made (Raptis et al., 2019). Authors explain efforts must be made to distribute security solutions, because data transference to a central controller may result in losses and delayed detection of potential threats. Hence, deviation should be quickly detected to mitigate potential damage (Raptis et al., 2019). Figure 6 summarizes data analysis capabilities discussed in industry 4.0 projects.

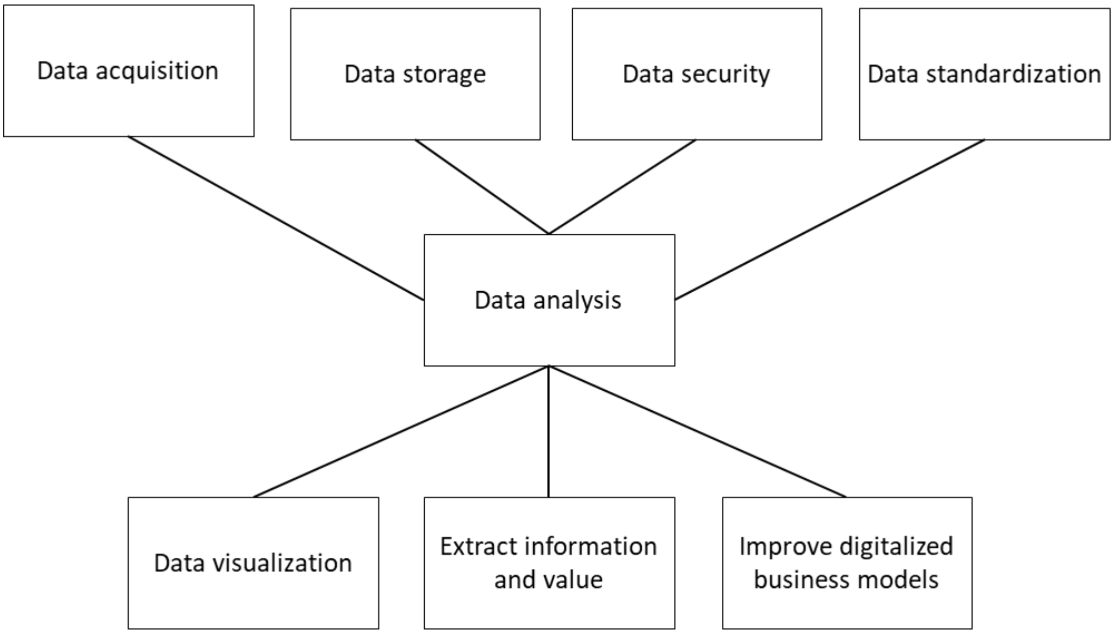

Figure 6: Data analysis capabilities of industry 4.0 projects

Source: Elaborated by the author

Data analysis and visualization to generate information and business value are backbones of industry 4.0 projects. However, they are supported by data acquisition, storage, security, and standardization. All these functions aim to improve digitalized business models and manufacturing processes.

2.1.7 PROJECT MANAGEMENT CAPABILITIES OF INDUSTRY 4.0 PROJECTS

Considered industry 4.0 is an evolutionary process that transforms technologies, professionals, business models and organizations (Kagermann et al., 2013), projects are single temporary initiatives responsible for delivering defined results (PMI, 2017). To guide industry 4.0 continuous improvement, a roadmap is suggested (Bibby & Dehe, 2018), and could be discussed by project portfolio management. As project portfolio is regarded instrumental to implement organization strategy (Bredillet et al., 2018). Hence, it could guide 4IR transformations.

In this context, projects are evaluated and selected to compose project portfolio, given they compete for scarce organization resources (Archer & Ghasemzadeh, 1999). One industry 4.0 study proposes a fuzzy approach to assist on project portfolio selection (Keskin, 2019), given the uncertainties and project interdependences on evolutionary industry 4.0. However, the study developed by Keskin (2019) focalizes on the mathematical calculations of portfolio selection, leaving unexplored other singularities of portfolio management in the context of industry 4.0.

On the other hand, Bertoncel, Erenda, and Mesko (2018) present a model to manage early warning signs, which resembles the structuring functions of portfolio management (Meskendahl, 2010). As such, their four-step model comprises a continuous search for new technology, qualitative and time-constraint evaluation, analysis of short and long-term returns on investment and selection of projects to be implemented. Although, Bertoncel, Erenda, and Mesko (2018) have not written from the perspective of project portfolio management.

Project management is seen as a structural capability for the effective implementation of industry strategic goals (de Sousa Jabbour et al., 2018; Holtgrewe, 2014; Rashid et al., 2018), as it contributes for successful and timely implementation of the 4IR (Ratzmann et al., 2018). Nevertheless, top management must be committed to the change process (Agostini & Nosella, 2019; Rashid et al., 2018; Yadegaridehkordi et al., 2018).

When studying the future of project management, Walker and Lloyd-Walker (2019) foresee project professionals implementing new technologies through industrial projects. They highlight professionals must evaluate project and organization at hand to adequate its management, since “one size does not fit all” (Sauser et al., 2009; Walker & Lloyd-Walker, 2019). This corroborates that project professionals shall think strategically (Walker & Lloyd-Walker, 2019), to fulfill executive positions (Pejic-Bach et al., 2019).

On single project implementation, Hasselblatt et al. (2018) state IoT suppliers must be able to deliver value as an asset. They put together turnkey solutions, according to state-of-the-art project management procedures, which combine technical knowledge on Information and Communication Technologies (ICT) and physical devices, aiming to fulfill customers’ needs. On these industry 4.0 projects, when a collaborative business network is established among equipment suppliers and manufacturing consumers, benefits and value co-creation are deepened (Agostini & Nosella, 2019).

Studying project success, Rashid et al. (2018) define critical factors for implementation of integrated information system. In their view, steering committees, project sponsors and multiskilled teams contribute to project success. Experienced steering committees, formed by key stakeholders, guide projects towards strategic goals, while project sponsors set project goals aligned to business case, negotiate resources and intervene to manage eventual resistances (PMI, 2017; Rashid et al., 2018). Multiskilled project teams, on the other hand, account for rich discussions when innovative ideas are challenged and refined (Ratzmann et al., 2018; Walker & Lloyd-Walker, 2019).

While Salehi (2020), and Park and Huh (2018), defend agile project management to improve project efficiency. Walker and Lloyd-Walker (2019) claim projects, either traditional or agile, will be managed more collaboratively. Figure 7 summarizes project management capabilities in industry 4.0 projects.

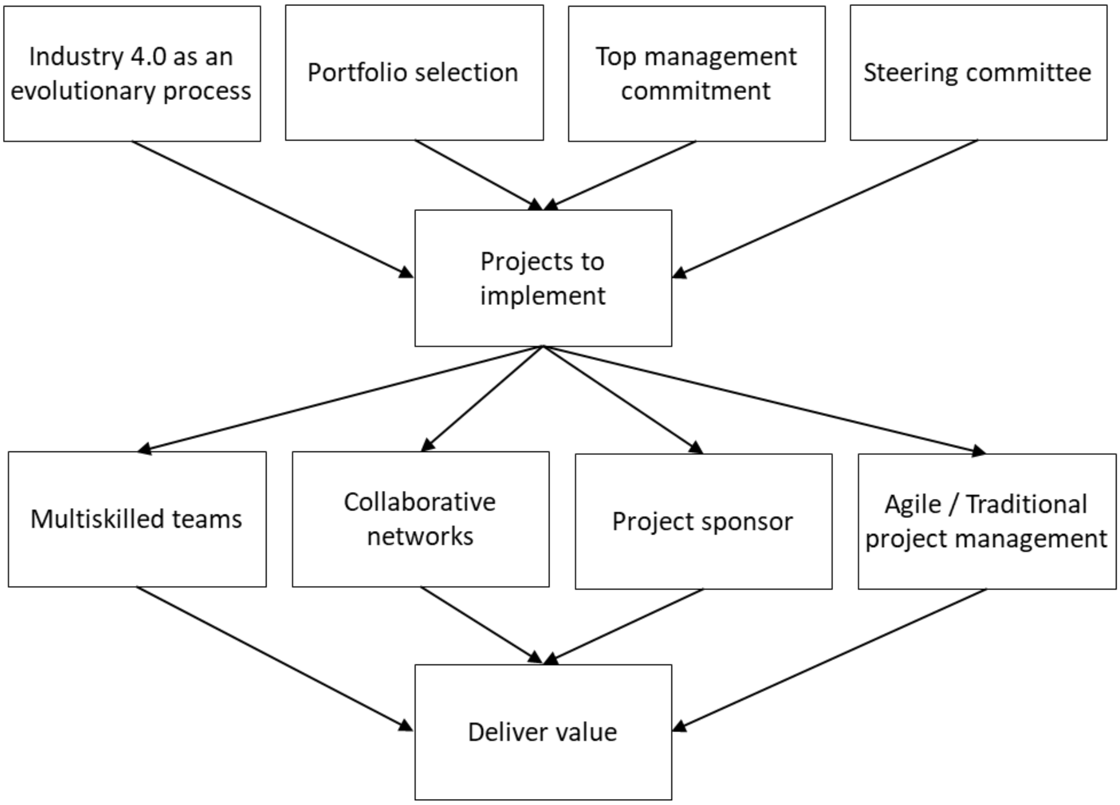

Figure 7: Project management capabilities of industry 4.0 projects

Source: Elaborated by the author

Industry 4.0 is an evolutionary long-term program. Hence, implementation of single industry 4.0 projects and program must be guided by portfolio selection and management to become instrument of company strategy. Top management support, steering committee, project sponsors and multiskilled teams are seen as key factors for industry 4.0 projects success. In this context project professional, through agile or traditional project management approaches, must collaborate to supplement their abilities and deliver value.

2.2 COLLABORATION AND PROJECT STAKEHOLDER MANAGEMENT

This subsection is partitioned, to organize the findings of the second SRL, detailed in Subsection 3.2. The first subsection defines project stakeholder management, while the second presents definitions for collaboration. Further on, the third subsection discusses collaboration and project stakeholder management.

2.2.1 DEFINITION OF PROJECT STAKEHOLDER MANAGEMENT

Stakeholders were first described in management literature as “those groups and individuals that can affect, or are affected by the accomplishment of organizational purpose” (Freeman, 1984, p. 25). Besides, Freeman´s seminal study also explains that each of these groups “have a stake” in the organization, hence the name “stakeholders”. Following, this concept was imported to project management studies (Cleland, 1985), defined as individuals and organizations affected by, or that may affect a project (Aaltonen & Kujala, 2016). Stakeholders establish relationships among them, which may also exert influence over projects (Aaltonen & Kujala, 2016).

A distinction may be drawn between internal and external stakeholders (Cleland, 1986). While internal stakeholders are positioned within the authority of project manager, such as team members, suppliers, subcontractors, and customers, external stakeholders are positioned outside the authority of project manager, like government authorities and community (Cleland, 1986). This research aims to explore the relationship between collaboration and stakeholder management in industry 4.0 projects, specifically among internal stakeholders.

Project stakeholder management identifies who project stakeholders are, to plan how to involve them with project decisions, while monitoring their engagement throughout project lifecycle (PMI, 2017). On a pragmatic view, project stakeholders are identified and analyzed aiming to maximize financial and nonfinancial resources, to prevent negative attitudes towards the project (Eskerod et al., 2015). However, a more collaborative view understands stakeholders’ concerns and interests are pillars for building win-win solutions (Eskerod et al., 2015).

Many techniques have been proposed to assist project stakeholder management (Bourne & Walker, 2008; Olander & Landin, 2005). The Stakeholder Circle, for example, assesses stakeholders' influence over the project, by drawing concentric circles to portray their distance and size relatively to project stakeholder environment (Bourne & Walker, 2008). Comprising five steps - identification, prioritization, visualization, engagement, and monitoring – aimed at improving stakeholder satisfaction. A different perspective analyzes power and influence of each project stakeholder (Olander & Landin, 2005), to prioritize project attention and engagement activities.

2.2.2 DEFINITION OF COLLABORATION

Authors have studied collaboration from different paradigms, from technical (Jay Lee et al., 2015), to social (Gladden, 2019). Although, this research adopts a management paradigm, in which collaboration targets shared outcomes, and encloses teamwork and coordination (Bedwell et al., 2012). To study collaboration among project stakeholders of industry 4.0, this study adopts Wood and Gray´s seminal definition (1991): "Collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain."

Project motivations for collaboration were studied by Walker and Rowlinson (2019). From an outer project viewpoint, they state high uncertainties, unknown risks, as well activities of emergency recovery may favor collaboration, because a wider range of decisions may be available to counteract emerging scenarios. On the other hand, from an intra project viewpoint, collaboration is supported by project outcomes clearly communicated, openness to innovative experimentation and establishment of social relationships (Walker & Rowlinson, 2019).

In this context, team integration and joint work are collaborative practices that promote structure for collaboration (Suprapto et al., 2015). These practices favor information and knowledge exchange among members (Baiden & Price, 2011). Summarizing, collaboration is an iterative process, in which common interests lead to shared identification of constraints and joint proposition of solutions (Kernel, 2005). Implementation of changes keeps the collaborative flare going, in a repeated virtuous cycle (Kernel, 2005).

2.2.3 COLLABORATION AMONG PROJECT STAKEHOLDERS

Literature about collaboration and project stakeholder management covers various industries (Azhar et al., 2012; Ika & Donnelly, 2017; Kernel, 2005; Nidumolu et al., 2014). From projects dealing with sustainability issues (Nidumolu et al., 2014), to technology commercialization projects (Zadeh et al., 2017). However, collaboration and project stakeholder management have been mainly discussed on construction and infrastructure projects (Azhar et al., 2012; Brunet & Forgues, 2019; Dedrick et al., 2000).

Most construction studies on collaboration debate Building Information Modelling (BIM) (Aranda-Mena et al., 2009; Mei et al., 2017) and Integrated Project Delivery (IPD) (Hanna, 2016; Walker & Lloyd Walker, 2016). BIM is a new technology that integrates construction stakeholders, in order to develop and update a virtual model of the construction building (Azhar et al., 2012). As an example of industry 4.0 virtual reality, it enables acquisition of building information by pointing mobile devices to construction elements (Azhar et al., 2012). Also, it boosts interoperability of information (Azhar et al., 2012).

To create the virtual model, communication among stakeholders, and their early involvement are seen as crucial success factors (Azhar et al., 2012; Brunet & Forgues, 2019), as well as stakeholders softer capabilities (Murphy & Nahod, 2017). Although, proactive measures shall be taken to mitigate integration risks (Azhar et al., 2012). For example, by adopting an IPD multiparty contract in which stakeholders share risks, rewards (Azhar et al., 2012; El Asmar et al., 2013; Walker & Rowlinson, 2019), and connect to define common goals (Mollaoglu et al., 2015; Xue et al., 2018).

Definition of shared goals is identified as a “common-glue” (Fellows & Liu, 2012) of collaborative project management (Faraj & Sambamurthy, 2006; Fellows & Liu, 2012; Gray, 1989; Ika & Donnelly, 2017; Kernel, 2005; Lin et al., 2018; Nidumolu et al., 2014). For example, on research projects bounding university and private sector, key stakeholders were reunited on initiation workshops, to align intentions and define matching project objectives (Fernandes et al., 2020). Public and private partners must acknowledge their risks and goals on collaborative projects (Adetola et al., 2013).

Discussing shared goals from an individual perspective, Faraj and Sambamurthy (2006), report that information technology projects rely on multiskilled professionals working on collaborative teams. In this context, empowering leadership promotes teamwork and consults with participants to make decisions, leading to participative definition of goals (Faraj & Sambamurthy, 2006). Stakeholders negotiate their self-interest goals towards shared common goals (Niebecker et al., 2010; Soh et al., 2011).

Fellows and Liu (2012) argue commitment to shared objectives is improved when stakeholders recognize their interdependence (Fellows & Liu, 2012; Kernel, 2005). Besides, when stakeholders actively participate on activities of project planning and goal definition, collaboration turns into a “catalyst” for early risk detection (Thamhain, 2012). Thus, stakeholders must be involved early with project discussions (Azhar et al., 2012; Cordeiro & Sogn-Grundvåg, 2019; El Asmar et al., 2013; Fellows & Liu, 2012; Gustavsson & Gohary, 2012).

Together with shared goals, information exchange is considered key to collaboration (Bond-Barnard et al., 2013; El-Gohary & El-Diraby, 2010; McGibbon et al., 2018; Soh et al., 2011; Xue et al., 2018). When stakeholders align their needs, information sharing is improved (Aranda-Mena et al., 2009; Gehrke, 2018). Soh et al.(2011), report increased opportunities for social informal interactions to target better cooperation among different stakeholders groups. On a more technical application, Kumaraswamy et al. (2004) presents a management support system claimed to facilitate information exchange on collaborative project management.

Information exchange is also fostered by constant connections across hierarchical levels, in organizational cultures that value direct communication (Herazo & Lizarralde, 2015). Attention, though, shall be paid to cultural differences that might hinder information exchange and communication (Nijhuis et al., 2012). When studying international collaboration to improve education in Ghana, Nijhuis et al. (2012) reported that cultural differences between Ghanaian and Dutch teams had to be counter measured by the adoption of face-to-face communications.

Corroborating the importance of face-to-face interactions, Senaratne and Sexton (2004) report project changes were discussed in detail during design meetings, despite previous exchange of information through email and telephone calls. In these meetings, different and complementary tacit knowledge, sometimes from previous experiences, were brought together to find a solution (Senaratne & Sexton, 2004). When stakeholders capabilities are interdependent, collaborative problem solving is boosted (Santos et al., 2012), and creativity is triggered (Barrett & Barrett, 2006; Liu et al., 2019), to overcome constraints (Barrett & Barrett, 2006).

In this context, executive committees and design meetings timely formalize active participation of stakeholders (Jung et al., 2015). Likewise, scenario development workshops (Fossum et al., 2019), and prototyping (Kpamma et al., 2018), promote discussions and facilitate iteration towards shared decisions. In these settings, resourceful professionals that quickly adapt to changes and conciliate misunderstandings participate on collaborative debate (Ika & Donnelly, 2017). Thus, joint problem solving is key for collaboration (Aarseth et al., 2012; González et al., 2015; Rijke et al., 2014), because it allows for collective ownership of decisions and shared responsibilities (Gray, 1989).

On transdisciplinary research projects, discussions and integration of different knowledges are essential, because stakeholders learn to work together, along the practical journey (Couix & Hazard, 2013). Through interactions, stakeholders develop stronger social bonds, that may turn into trust (Shelley & Maqsood, 2014). When project teams have previous working relationships, teamwork is facilitated (Senaratne & Sexton, 2004), while communication foster long-term relationships among stakeholders (Zuo et al., 2009). From a different perspective, Thamhain (2012) highlights teamwork and mutual trust as important factors contributing to effective risk management.

Other studies highlight the relationship between trust and collaboration (Fellows & Liu, 2012; Nidumolu et al., 2014; Santos et al., 2012; Thamhain, 2012; Walker & Lloyd Walker, 2016). Trust is promoted by project stakeholder management (Oliveira & Rabechini, 2019), which, on a virtuous circle, improves knowledge sharing (Santos et al., 2012). Nevertheless, cause and effect relationship between trust and collaboration rests to be further studied (Fossum et al., 2019).

On a practical summary for collaboration among stakeholders, Nidumolu et al. (2014) advise that stakeholders entering collaborative projects should begin with small, committed and mutual trusted groups. Despite acknowledging their own benefits, stakeholders must realize which benefits are pursued by the collaborative initiative (Nidumolu et al., 2014). Authors also argue collaborative quick wins generate momentum, for pursuing long-term goals.

When shared goals are perceived as feasible, commitment is increased (Kernel, 2005). Collaborative stakeholder management is seen to improve cost performance, while leading to stronger relationships among stakeholders (Xue et al., 2018). Yet on performance, El Asmar et al. (2013) found collaborative IPD has superior quality performance, compared to Design-Build or Design-Bid-Build. Thus, collaborative stakeholders tend to be more satisfied (Aranda-Mena et al., 2009; Serrador & Pinto, 2015).

Satisfaction of stakeholders and project efficiency were compared in agile and traditional project management by Serrador and Pinto (2015). According to these authors, agile focus on customer collaboration rather than formal contracts; individuals and interactions rather than process; has returned higher project success. Greater iteration and upfront planning have improved project success (Serrador & Pinto, 2015).

2.3 KEY FACTORS CONNECTTING COLLABORATION AND STAKEHOLDER MANAGEMENT IN INDUSTRY 4.0 PROJECTS

Capabilities and project management, in the context of industry 4.0, intersect around collaboration among stakeholders, from macro through to team and individual levels (Agostini & Nosella, 2019; Campatelli et al., 2016; Moeuf et al., 2018). Nevertheless, no industry 4.0 study has researched into it. Thus, literature about collaboration and project stakeholder management supports, in wider contexts, this empirical research plan.

Various factors connect collaboration and project stakeholder management. Among others definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), early involvement of stakeholders (Azhar et al., 2012; Serrador & Pinto, 2015), recognition of stakeholders' interdependence (Fellows & Liu, 2012; Kernel, 2005), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012). Also, adaptability (Ika & Donnelly, 2017; Rijke et al., 2014), information exchange (Brunet & Forgues, 2019; Liu et al., 2019), collective learning (Couix & Hazard, 2013; Herazo & Lizarralde, 2015) and establishment of trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012).

Verifying the convergence of these factors in industry 4.0 literature, four preliminary factors are singled out to connect collaboration and stakeholder management: definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012), information exchange (Brunet & Forgues, 2019; Liu et al., 2019) and trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012). Hence, a preliminary research model is presented in Figure 8.

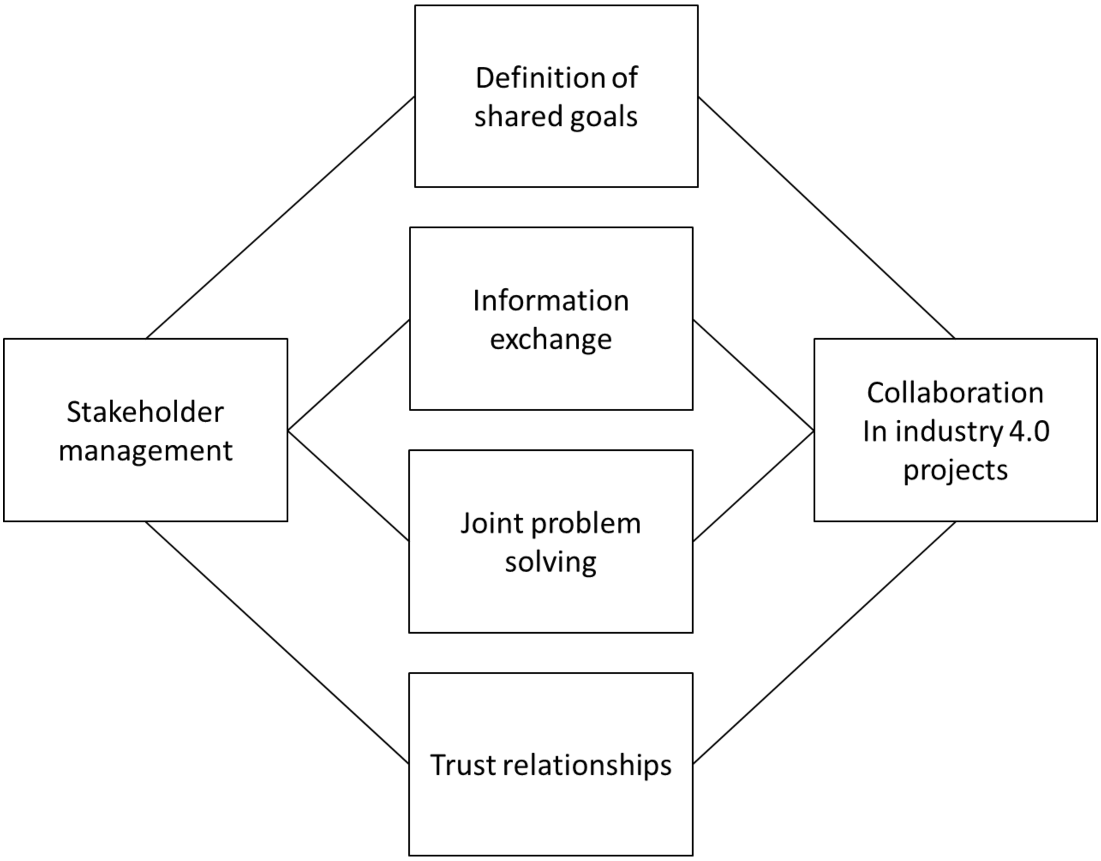

Figure 8: Preliminary empirical research model

Source: Elaborated by the author

These factors permeate literature about capabilities and project management in the context of industry 4.0 projects, as well as literature about collaboration and project stakeholder management in broader contexts. They were selected to comprise the preliminary research model due to their relevance on reviewed literature, although, researcher interpretation and sampling bias must not be disregarded. Frame 1 presents studies in which these factors are highlighted.

Factor	Definition	Article
Definition of shared goals	Clear definition of common goals.	(Aarseth et al., 2012; Aranda-Mena et al., 2009; Caruso, 2018; Faraj & Sambamurthy, 2006; Fellows & Liu, 2012; Gray, 1989; Ika & Donnelly, 2017; Kernel, 2005; Nidumolu et al., 2014; Ratzmann et al., 2018; Suprapto et al., 2015; Walker & Rowlinson, 2019)
Information exchange	Interaction and communication leading to open exchange of information among project stakeholders.	(Bond-Barnard et al., 2013; Campatelli et al., 2016; El-Gohary & El-Diraby, 2010; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Rashid et al., 2018; Ratzmann et al., 2018; Singh et al., 2019; Sjödin, 2019; Soh et al., 2011; Walker & Lloyd-Walker, 2019; Xue et al., 2018)
Joint problem solving	Work together, assessing risks and experimenting. Taking into consideration complementary knowledge, experience, and perspectives.	(Aarseth et al., 2012; Couix & Hazard, 2013; González et al., 2015; Gray, 1989; Ika & Donnelly, 2017; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Rijke et al., 2014; Santos et al., 2012; Senaratne & Sexton, 2004; Sjödin, 2019)
Trust relationships	Establishment of relationship-based interactions, leading to trust among stakeholders.	(Ika & Donnelly, 2017; Moeuf et al., 2019; Nidumolu et al., 2014; Nikitina & Lapiņa, 2019; Parida & Wincent, 2019; Ratzmann et al., 2018; Rijke et al., 2014; Roßmann et al., 2018; Santos et al., 2012; Thamhain, 2012; Walker & Lloyd-Walker, 2019; Xue et al., 2018)

Frame 1: Factors connecting collaboration and stakeholder management

Source: Elaborated by the author

These factors agree with features listed by Gray (1989) that characterizes collaboration as an emergent process. In her study, she establishes that when independent stakeholders, with different opinions, engage in constructive debate, solutions for problems surface. Leading to joint ownership and shared responsibilities for future outcomes (Gray, 1989).

3 RESEARCH METHOD

This section details methods supporting this research project, which is planned to be conducted in five phases. According to Figure 9, the first two phases involve literature research. The third phase comprises the proposition of a preliminary research model. While the fourth phase involves exploratory, inductive, and qualitative empirical interventions. Finally, the fifth phase proposes a research model that explores the relationship between collaboration and stakeholder management in industry 4.0 context. In order to organize method description, subsections discuss research phases.

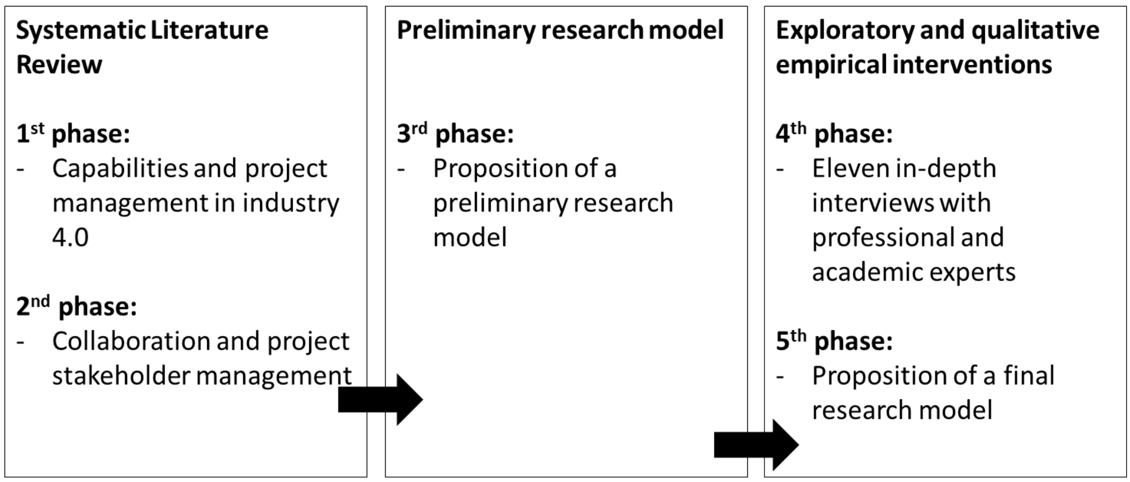

Figure 9: Proposed phases for this research project

Source: Elaborated by the author

The first phase involves elaboration of an SRL, analyzing 55 articles about capabilities and project management in the context of industry 4.0. The second phase comprises another SRL, examining other 46 articles about collaboration and project stakeholder management, in wider contexts. As a result, information from both bodies of literature intersect to support the proposition of a preliminary research model, in the third phase of this research project. The fourth phase of this research project comprises exploratory and qualitative in-depth interviews with academics and professional experts. Lastly, the fifth phase established a research model based on empirical findings and previous literature.

3.1 SRL OF CAPABILITIES AND PROJECT MANAGEMENT IN INDUSTRY 4.0

An SRL about capabilities and project management, in the context of industry 4.0, initiated this research project. The undertaken procedures are summarized in the protocol shown in Figure 10, based on the scale for analyzing the quality of SLRs, according to Costa et al. (2015). In this method, the researcher accesses and analyzes related past studies in pursue of knowledge gaps, rendering transparency and reproducibility to the research (Tranfield et al., 2003).

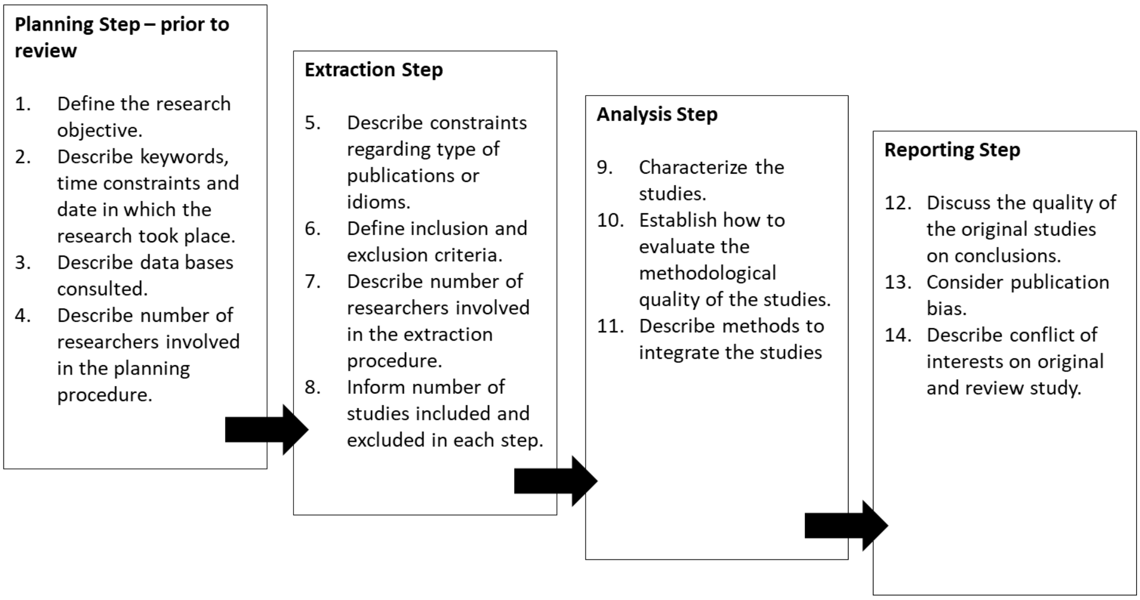

Figure 10: Protocol for SRL

Source: Elaborated by the author, based on Costa et al. (2015)

The research protocol comprises four macro steps: planning, extraction, analysis and reporting the literature review. During the planning step, the objective of the review was clearly defined (Costa et al., 2015). Thus, the purpose of the SRL was set on understanding how capabilities and project management had been studied in the context of industry 4.0 manufactures.

Still in the planning step, a Boolean search was elaborated to combine keywords and synonyms related to industry 4.0, project management and capabilities (Costa et al., 2015). Keyword were selected to produce a comprehensive catalog of studies, taken extra care to determine relevant synonyms for industry 4.0, given it is a recent initiative. Specifically, the preliminary search for industry 4.0 adopted the expression (“four* indust* revol*” OR “4* indust* revol*” OR “Indust* 4*”).

Results were analyzed using the R-studio application “biblioshiny”, and as an outcome, two more keywords were included into the initial string: synonyms for smart factory and smart manufacturing. The expression (("four* indust* revol*" OR "smart factor*" OR "smart manufact*" OR "industr* 4*" OR "4* indust* revol*") AND ("project* manag*" OR "manag* of project") AND (capabil* OR compet* OR skill*)) was validated by two PhD researchers, specialized on industry 4.0 studies and project management, respectively. Hence, it was used to acquire the catalog of studies for this review.

In September 2019, Scopus and Web of Science data bases were consulted, not restrict to subjects, title and keywords, returning 435 and 3 documents, respectively (Costa et al., 2015). No time constraint was established, given the body of research only included documents published after 2014. To ensure the literature review would be based on reliable studies, extracted documents were restricted to peer-reviewed articles published on journals. Thus, quantities of documents were reduced to 203 articles from Scopus and 1 article from Web of Science, this last comprised within Scopus extraction.

Into the extraction step, the data base with 203 articles was downloaded to Excel. The next activity involved reading all abstracts to establish inclusion and exclusion criteria (Costa et al., 2015). To focalize the research body, articles on civil construction, cities, government, and country policies were excluded from the main research extract. Besides, articles not available in Portuguese or English, as well as detailed studies on supply chain management, were also excluded.

Again, definition of exclusion criteria was overseen by two PhD researchers, specialized on industry 4.0 studies and project management, respectively (Costa et al., 2015). Hence, these activities ensured that articles further analyzed comprised only studies about capabilities and project management, discussing industry 4.0 in the context of manufactures.

Into the analysis step, 89 articles, from three main areas of knowledge - management, engineering, and computer science, compose the research body. They were carefully read, and those only briefly debating the subjects, with deficient methodology or those not contributing to the research objectives were further excluded. As a result, 34 other articles were excluded, lasting 55 peer reviewed articles, as the final corpus of the SRL. Reviewed articles have been published from 2014 onwards, as shown in Figure 11.

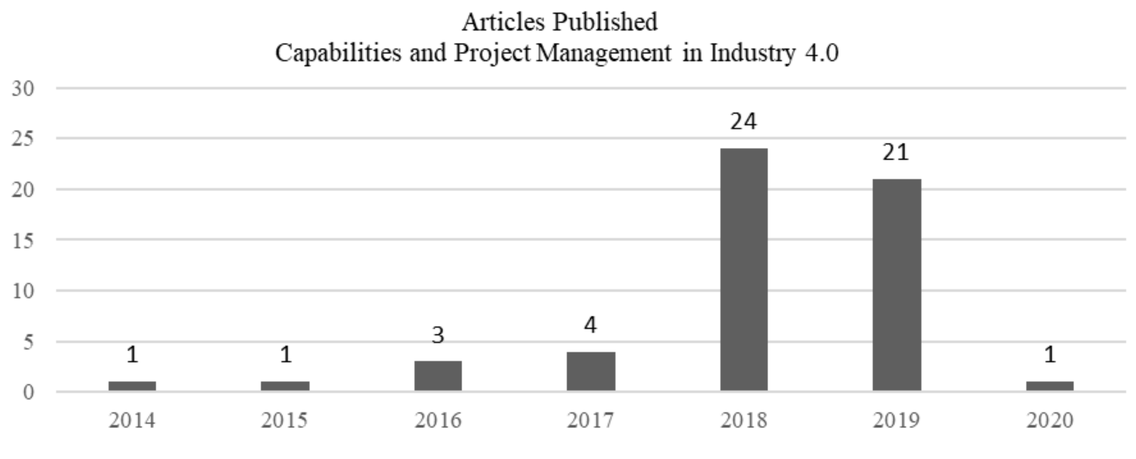

Figure 11: Number of articles published yearly

Source: Elaborated by the authors

After a steep increase from 2017 to 2018, the ascendant trend continues, reaching roughly the same number of articles in September 2019 as published in the year before. Following, reviewed articles were classified in terms of their research approach, as shown in Table 1. Exploratory studies, such as qualitative studies, literature reviews and conceptual articles represent 83% of the research corpus. Concentration of exploratory studies could be explained, because knowledge about the organizational phenomena being studied is still incipient (Creswell, 2010).

Research approach	Number of articles	%	Accum. %
Qualitative	27	48%	
Conceptual	10	14%	62%
Literature review	9	21%	83%
Quantitative	6	12%	95%
Mixed methods	3	5%	100%
Total	55	100%	

Table 1: Distribution of articles per research approach

Source: Elaborated by the authors

Hence, based on information from Figure 11 and Table 1, as a finding from SRL this study establishes research about capabilities and project management, in the context of industry 4.0 manufactures, is in its infancy, having gained interest over the last years. On a second step of analysis, the 55 articles were preliminarily coded using ATLAS.ti, which is a qualitative research software, to facilitate identification of text fragments or incidents and their analysis by the researcher.

Once open coding was concluded, quotations were downloaded to Excel where they were synthesized around six perspectives of capabilities: strategic, innovation, human, technological, data analysis and project management. Frame 2 presents each reviewed article, classifying them into the proposed perspectives of capabilities (Costa et al., 2015).

Reviewed article	Project management (PM)	Strategic (ST)	Innovation (IN)	Human (HU)	Technologies (TE)	Data analysis (DA)
(Moeuf et al., 2018)		ST			TE	
(de Sousa Jabbour et al., 2018)	PM	ST		HU		
(Ooi et al., 2018)		ST	IN		TE	
(Kuo & Smith, 2018)		ST			TE	
(Roßmann et al., 2018)		ST		HU		DA
(Wang et al., 2018)					TE	
(Yadegaridehkordi et al., 2018)	PM				TE	DA
(Hasselblatt et al., 2018)	PM	ST		HU		DA
(Rashid et al., 2018)	PM	ST		HU		
(Ho & O'Sullivan, 2017)		ST	IN			DA
(Caruso, 2018)	PM			HU		
(Ferreira et al., 2017)		ST				
(Bibby & Dehe, 2018)	PM				TE	
(Walker & Lloyd-Walker, 2019)	PM					
(Sjödin, 2019)	PM		IN	HU		
(Bertoncel, Erenda, Bach, et al., 2018)		ST	IN	HU		
(Ratzmann et al., 2018)	PM		IN	HU		
(Qu et al., 2019)		ST				DA
(Parida & Wincent, 2019)		ST				DA
(Shivajee et al., 2019)						DA
(Li et al., 2019)		ST		HU		DA
(Nikitina & Lapiņa, 2019)			IN	HU		
(Pejic-Bach et al., 2019)	PM					
(Agostini & Nosella, 2019)		ST		HU		
(Moeuf et al., 2019)	PM	ST		HU		
(Raptis et al., 2019)						DA
(Singh et al., 2019)	PM	ST		HU		
(Briones-Peñalver et al., 2019)	PM	ST	IN	HU		
(Goh et al., 2019)					TE	
(Chehbi-Gamoura et al., 2019)		ST				DA
(Villalba-Diez et al., 2018)		ST				
(Lerch & Gotsch, 2015)		ST	IN			DA
(Holtgrewe, 2014)	PM			HU		
(Parviainen et al., 2017)		ST				
(Park & Huh, 2018)	PM					
(Campatelli et al., 2016)			IN	HU		
(Fettermann et al., 2018)					TE	
(Bernstein et al., 2018)						DA
(Gunckel et al., 2018)						DA
(Rejeb et al., 2019)		ST			TE	

Reviewed article	Project management (PM)	Strategic (ST)	Innovation (IN)	Human (HU)	Technologies (TE)	Data analysis (DA)
(Keskin, 2019)	PM					
(Synnes & Welo, 2016)		ST	IN	HU		
(Roblek et al., 2016)		ST				DA
(Bressanelli et al., 2018)		ST				DA
(Olszak & Mach-Król, 2018)						DA
(Bertoncel, Erenda, & Mesko, 2018)	PM	ST		HU		
(Yun & Liu, 2019)		ST	IN			
(J. M. Müller & Voigt, 2018)						DA
(Salehi, 2020)	PM		IN			
(Garcia-Muiña et al., 2019)		ST				DA
(Tarifa-Fernández et al., 2019)		ST				
(Siddoo et al., 2019)				HU		
(Dewa et al., 2018)		ST				
(Bag, 2018)		ST				
(Hannola et al., 2018)			IN			

Frame 2: Articles about capabilities and project management

Source: elaborated by the author

As another finding, the SLR about capabilities and project management indicated industry 4.0 initiatives overlap around collaboration among parties, from strategic through to human dimensions. Besides, it was identified project management supports industry 4.0 implementation. Therefore, the empirical research question was formulated to explore the relationship between project stakeholder management and collaboration in industry 4.0.

3.2 SRL OF COLLLABORATION AND PROJECT STAKEHOLDER MANAGEMENT

In order to reach the main objective of this research, another SRL has explored 46 peer-reviewed articles about collaboration and project stakeholder management. Likewise, procedures presented in Figure 10 were followed (Costa et al., 2015), to systematically analyze past studies, supporting transparent and reproducible research method (Tranfield et al., 2003), Thus, planning, extraction, analysis and reporting macro steps were observed.

Planning next activities, the purpose of the review was stated (Costa et al., 2015). It aimed to described key factors influencing the relationship between collaboration and project stakeholder management. Following, a Boolean search combined keywords related to the main subjects (Costa et al., 2015). The expression (collab* AND stakeholder* AND "project manag*") was validated by a PhD researcher specialized on project stakeholder management. Then, Scopus database was consulted, in March 2020, and returned 568 documents (Costa et al., 2015).

Search was limited to peer-reviewed articles, related to the areas of knowledge of business and management. Restricting the research body to 96 articles, they were downloaded to Excel into the extraction step. Following, all abstracts were read to establish inclusion and exclusion criteria (Costa et al., 2015). Again, definition of exclusion criteria was overseen by a PhD researcher, specialized on project stakeholder management (Costa et al., 2015). As a result, 18 articles describing collaborative research projects, that did not discuss aspects of collaboration among project stakeholder were eliminated. Also, it was not possible to retrieve three other articles. At last, the analysis research body comprised 75 articles.

Articles were carefully read, and those only briefly discussing the subjects, with deficient methodology or not contributing to the research objectives were further excluded. As a result, 29 other articles were excluded, lasting 46 peer reviewed articles, as the final corpus of the SRL. Again ATLAS.ti and Excel were used to extract factors connecting collaboration and project stakeholder management and compare them with factors mentioned on industry 4.0 research body.

As a result, four factors were found to intersect both research bodies. Frame 3 shows each reviewed article, in the context of SLR about collaboration and project stakeholder management that mentions the following factors: definition of shared goals, information exchange, joint problem solving and trust relationships (Costa et al., 2015).

Reviewed articles	**Shared Goals (SG)**	**Information Exchange (IE)**	**Joint Problem Solving (JPS)**	**Trust Relationships (TR)**
(Azhar et al., 2012)	SG	IE	JPS	
(Serrador & Pinto, 2015)	SG	IE	JPS	
(El Asmar et al., 2013)	SG	IE		
(Aranda-Mena et al., 2009)	SG	IE		
(Thamhain, 2012)		IE	JPS	TR
(Faraj & Sambamurthy, 2006)	SG	IE	JPS	
(Fellows & Liu, 2012)	SG	IE		TR
(Soh et al., 2011)	SG	IE	JPS	
(Kernel, 2005)	SG	IE	JPS	
(Senaratne & Sexton, 2004)		IE	JPS	TR
(Santos et al., 2012)		IE	JPS	TR

Reviewed articles	Shared Goals (SG)	Information Exchange (IE)	Joint Problem Solving (JPS)	Trust Relationships (TR)
(Zuo et al., 2009)		IE		TR
(Ika & Donnelly, 2017)	SG	IE	JPS	TR
(Hanna, 2016)		IE		
(El-Gohary & El-Diraby, 2010)		IE		
(Jung et al., 2015)	SG	IE	JPS	TR
(Walker & Lloyd Walker, 2016)	SG	IE	JPS	TR
(Kumaraswamy et al., 2004)		IE		TR
(Nidumolu et al., 2014)	SG	IE	JPS	TR
(Gustavsson & Gohary, 2012)		IE	JPS	
(Aarseth et al., 2012)	SG	IE	JPS	TR
(Couix & Hazard, 2013)		IE	JPS	TR
(Xue et al., 2018)	SG	IE		TR
(Rijke et al., 2014)	SG	IE	JPS	TR
(Bond-Barnard et al., 2013)		IE		TR
(González et al., 2015)		IE	JPS	
(Dedrick et al., 2000)	SG	IE	JPS	
(Mollaoglu et al., 2015)	SG		JPS	TR
(Nijhuis et al., 2012)	SG	IE	JPS	TR
(Niebecker et al., 2010)	SG	IE	JPS	TR
(Lin et al., 2018)	SG	IE		TR
(Herazo & Lizarralde, 2015)	SG	IE	JPS	
(Mei et al., 2017)	SG	IE		TR
(Barrett & Barrett, 2006)	SG	IE	JPS	TR
(Adetola et al., 2013)	SG	IE		TR
(Liu et al., 2019)	SG	IE	JPS	TR
(Kpamma et al., 2018)	SG	IE	JPS	TR
(Brunet & Forgues, 2019)	SG	IE	JPS	TR
(Murphy & Nahod, 2017)	SG			TR
(Shelley & Maqsood, 2014)		IE		TR
(Cordeiro & Sogn-Grundvåg, 2019)	SG	IE		
(McGibbon et al., 2018)		IE		
(Fernandes et al., 2020)	SG	IE		TR
(Fossum et al., 2019)	SG	IE	JPS	
(Gehrke, 2018)	SG	IE		
(Zadeh et al., 2017)		IE	JPS	

Frame 3: Articles about collaboration and project stakeholder management

Source: elaborated by the author

Different from the first SRL, this second procedure was less exploratory. Considering its aim was more focused to support empirical research objective. Once factors connecting collaboration and stakeholder management in industry 4.0 were enlisted, a preliminary research model was proposed to guide data collection and analysis (Yin, 2013), on the third phase of this research project.

3.3 EMPIRICAL QUALITATIVE RESEARCH

The fourth phase of this research project foresees exploratory and qualitative empirical interventions. In depth interviews were carried out with academic and professional experts to capture their perspective about the relationship between collaboration and stakeholder management in industry 4.0 projects, mainly in the manufacturing sector, but also in other sectors. Interview transcripts were analyzed to retrofit the preliminary research model.

Qualitative researcher collects data from different perspectives intending to make sense of the subject, through the perspective of participants (Godoy, 1995). It supports an inductive process of analysis (Godoy, 1995), in which patterns and categories are formed from the bottom up, towards more abstract concepts (Creswell, 2010). Different perspectives are described in detail, to recreate complex and holistic reports, aiming to share with readers the experience of the research (Creswell, 2010). However, qualitative research is also an interpretative process, because researchers' previous experiences are not detached from results (Creswell, 2010).

3.3.1 UNIT OF ANALYSIS

The unit of analysis of this exploratory research are industry 4.0 projects. In the context of recent phenomena, like the 4IR (Kagermann et al., 2013), exploratory approaches are most applicable. Considered not much is known about the subject (Godoy, 1995), researchers aim to gather more information and find patterns that would improve knowledge about it (Yin, 2013).

3.3.2 INTERVIEWS WIH ACADEMIC AND PROFESSIONAL EXPERTS

This research project adopts in-depth interviews as its research strategy, which constitute relevant sources of experiences, facts and points of view (Turner, 2010). Perspectives of academic and professional experts on the theoretical axes of this study: industry 4.0, project stakeholder management and collaboration are explored. Further on, data collection and data analysis procedures are detailed.

3.3.2.1 DATA COLLECTION PROCEDURE

Different approaches were chosen to select academics and practitioners as potential interviewees. For academics, Scopus database was searched to identify which researchers in Brazil had publish about industry 4.0, industry 4.0 and stakeholder management, as well as industry 4.0 and collaboration. Then, 2 or 3 academics in each area of expertise were contacted via email, ResearchGate or LinkedIn. Those that accepted the invitation were interviewed.

On the other hand, to identify practitioners with experience in industry 4.0 projects, we initiated looking for companies and professionals with highlighted initiatives. Academic articles, white papers and institutional websites were searched to identify such companies operating in Brazil. Besides, specific practitioners were recommended by academic peers, considering previous experience with industry 4.0 projects.

Thus, a list of potential companies and practitioners was organized, aiming to balance the theoretical axes of research (Creswell, 2010). A presentation letter was sent electronically to explain the research focus (ANNEX 1) and invite selected interviewees to participate. Finally, interviews were scheduled, considering academics and practitioners experience and potential to contribute. Profile of interviewees is presented in Frame 4, together with main reason for their selection.

Interviewee ID	Academic / Practitioner	Occupation	Area of expertise / Economy sector	Main reason for selection
I1	Academic	University professor	Production engineering PhD	Peer-reviewed publications about industry 4.0.
I2	Practitioner	Project manager	Elevators manufacture	New business model application. Company offers a digital solution for elevator clients.
I3	Academic	Director of a Postgraduation program	Production engineering PhD	Peer reviewed publications about project management and industry 4.0.
I4	Practitioner	Vice president of operations	Resins and dispersions manufacture	Company exhibits various industry 4.0 initiatives.
I5	Practitioner	Compliance coordinator	Automotive manufacture	Practitioner deals with artificial intelligence projects.
I6	Practitioner	Engineering coordinator	Engineering consultancy	Company has implemented industry 4.0 projects.
I7	Academic	Professor at Technology institute	Specialist in industry 4.0 and digitalization	Technology Professor, specialized on industry 4.0.
I8	Academic / Practitioner	Post-doctoral student / Manufacturing automation consultant	Administration PhD / Automation consultancy	Project management and industry 4.0 academic and professional experience.
I9	Practitioner	Digital manager for Latin America	Agriculture chemicals manufacture	New business model application. Company offers industry 4.0 solutions for agriculture customers.
I10	Practitioners	Head of industry 4.0 for Latin America (I10A) and IT Portfolio Manager (I10B)	Automotive manufacture	Company is recognized on the forefront of industry 4.0 by The World Economic Forum.
I11	Academic	PhD researcher	Administration PhD	Peer reviewed publication on industry 4.0 and open innovation.

Frame 4: Profile of interviewees

Source: elaborated by the author

Most interviewees have a manufacturing background, academic or professional, except Interviewee 6. However, Interview 6 brings out a different perspective on industry 4.0 projects, coming from construction or engineering projects. This perspective is compared with manufacturing perspective in Section 4.1.1.5.2. Considered those profiles, semi-structured interviews have taken place from July to October 2020. They lasted from 13 to 77 minutes, with recordings authorized by interviewees. Frame 4 presents interviews duration and associated number of pages in transcripts.

Interviewee ID	Academic / Practitioner	Duration of interview	Number of pages on transcript
I1	Academic	13 min	5 pages
I2	Practitioner	20 min	8 pages
I3	Academic	1h e 17min	11 pages
I4	Practitioner	41 min	10 pages
I5	Practitioner	50 min	14 pages
I6	Practitioner	49 min	9 pages
I7	Academic	17 min	5 pages
I8	Academic / Practitioner	1h e 12 min	13 pages
I9	Practitioner	23 min	6 pages
I10	Practitioners	56 min	15 pages
I11	Academic	1h e 8 min	14 pages

Frame 5: Duration of interviews and number of pages on transcript

Source: elaborated by the author

A single academic or practitioner was interviewed in each event, except on Interview 10, when two practitioners from the same company were heard. During interviews, reflections and interpretations were noted down on a research diary (Creswell, 2010). Besides, interviews were guided by a protocol comprised of thirteen questions (Frame 6). Questions target investigation of events, processes, behaviors and activities, by means of systematic procedures bringing rigor to qualitative research (Creswell, 2010). Thus, protocol was structured in three blocks to explore: industry 4.0 projects, stakeholder management practices and factors regarding collaboration.

Objective	Theoretical background	Authors	Question
Characterize industry 4.0 projects	Industry 4.0 may be seen as a transformation wave, in which digital technologies integrate production chains and manufacturing companies in collaborative business models centered on services.	(Agostini & Nosella, 2019; Ferreira et al., 2017; Hasselblatt et al., 2018; Lerch & Gotsch, 2015; Moeuf et al., 2019; Parida & Wincent, 2019; Ratzmann et al., 2018; Schumacher et al., 2016; Walker & Lloyd-Walker, 2019)	1. How would you briefly characterize an industry 4.0 project? 2. How you explain the difference between automation projects and industry 4.0 projects? 2. Could you characterize an industry 4.0 project in which you participated?

Objective	Theoretical background	Authors	Question
Characterize stakeholder management practices	Stakeholders are people or organizations that influence or are influenced by projects. Throughout project' lifecycle, stakeholders are identified and classified, thus their engagement may be monitored.	(Aaltonen & Kujala, 2016; Bourne & Walker, 2008; Eskerod et al., 2015; Olander & Landin, 2005; PMI, 2017)	4. Could you characterize the different stakeholders in this industry 4.0 project, considering their influence and power? 5. Which stakeholder management practices were employed in this industry 4.0 project in which you participated? 6. How did you engage project stakeholders?
Considering collaboration, characterize how project goals were defined	Clear definition of common goals, aligned with organizational strategy.	(Aranda ‐ Mena et al., 2009; Faraj & Sambamurthy, 2006; Fellows & Liu, 2012; Gray, 1989; Ika & Donnelly, 2017; Kernel, 2005; Nidumolu et al., 2014; Ratzmann et al., 2018; Suprapto et al., 2015; Walker & Rowlinson, 2019)	7. How were project goals established? 8. How did stakeholders participate?
Considering collaboration, understand how information was exchanged	Interaction and communication leading to open sharing of information among project stakeholders.	(Bond-Barnard et al., 2013; Campatelli et al., 2016; El-Gohary & El-Diraby, 2010; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Rashid et al., 2018; Ratzmann et al., 2018; Singh et al., 2019; Sjödin, 2019; Soh et al., 2011; Walker & Lloyd-Walker, 2019; Xue et al., 2018)	9. How was information exchanged between project stakeholders?
Considering collaboration, understand how problems were solved?	Work together, assessing risks and experimenting. Taking into consideration complementary knowledge, experience, and perspectives.	(Aarseth et al., 2012; González et al., 2015; Gray, 1989; Ika & Donnelly, 2017; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Rijke et al., 2014; Santos et al., 2012; Senaratne & Sexton, 2004; Sjödin, 2019; Suprapto et al., 2015)	10. How eventual problems or unplanned situations were dealt with? 11. How did stakeholders participate?
Considering collaboration, how trust relationships were established	Establishment of relationship-based interactions, leading to trust among stakeholders.	(Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Parida & Wincent, 2019; Ratzmann et al., 2018; Roßmann et al., 2018; Walker & Lloyd Walker, 2016; Xue et al., 2018)	12. How well did project stakeholders trust each other?
Understand how collaboration is regarded.	Collaboration occurs when autonomous stakeholders use common rules to act and decide on a problem that affects them.	(Baiden & Price, 2011; Bedwell et al., 2012; Suprapto et al., 2015; Wood & Gray, 1991)	13. What activities and practices facilitated collaboration in the project?

Frame 6: Interview protocol

Source: elaborated by the author

Although the interview protocol organizes planned interventions, it does not limit improvised or probing questions that might explore emergent subjects (Creswell, 2010). Hence, additional questions were formulated depending on the context being discussed. Each recorded interview was transcribed, preparing it for data analysis. Also, targeting to enhance research validity, transcripts were sent to interviewees in November 2020, for verification. Some interviewees returned with small comments that were incorporated to final transcripts.

3.3.2.2 DATA ANALYSIS PROCEDURE

Data analysis started during transcript translation, mainly supported by coding, which took place in three steps: open, axial, and selective coding (Bandeira-de-Mello & Cunha, 2003; Corbin & Strauss, 2007). During translation, research diary was also used to register main issues discussed in each interview, as well as issues emerging as convergent among them. As interview protocol was defined based on a literature background, initial concepts during open coding were already in place to be marked and classified. Thus, as a theory driven starting point, an initial codebook was drawn (Frame 7). Transcripts were uploaded to ATLAS.ti,

Concepts	Initial Codebook
Industry 4.0 projects	Industry 4.0 projects
	Automation versus Industry 4.0
Project stakeholder management	Key stakeholders
	Stakeholder engagement
Collaboration	Definition of project objectives
	Information exchange
	Joint problem solving
	Trust relationship
	Collaboration

Frame 7: Initial codebook

Source: elaborated by the author

The first round of open coding started, identifying relevant fragments of interviewees speech as incidents, and assigned either to one initial code or left still marked as free citation (Bandeira-de-Mello & Cunha, 2003; Corbin & Strauss, 2007). Incidents were evaluated and compared, searching for similarities and differences, to classify them as an emergent code, and aiming to group codes as more abstract categories and concepts (Corbin & Strauss, 2007). Once the second round of open coding was concluded, 23 other emergent codes were identified (Creswell, 2010).

At this point, citations and their respective codes were downloaded from ATLAS.ti to an Excel spreadsheet where an unexperienced qualitative researcher was more familiarized. Aiming to report results from broader to specific perspective, codes referring to industry 4.0 projects in general were identified. Synonyms for industry 4.0 projects referred during interviews were registered to assure homogeneous understanding, despite the use of different synonyms. Besides, speeches referring to industry 4.0 projects as guided by two forces, technological and a business related, were also identified and described (Lasi et al., 2014). Both contents are detailed in Section 4.1.1.1.

Focusing a bit more on reported industry 4.0 projects, they were registered, assigned to each interview, employed technologies were defined, and projects were classified in terms of their maturity application (Moeuf et al., 2019; Porter & Heppelmann, 2014), for further analysis. Still on this broader view of industry 4.0 projects, the role of data was identified from interviews and highlighted, because data emerged as a relevant feature of industry 4.0 projects and their evolution process. These findings are also presented in Section 4.1.1.1.

Getting down to register factors connecting collaboration and stakeholder management described on interviews, it was decided each project would be characterized individually. These projects are characterized in Section 4.1.1.2. Thus, each project was combed to identify factors connecting collaboration and stakeholder management, including factors referring to organizational context which might affect collaboration and stakeholder management. Manufacturing projects are reported in Section 4.1.1.3.

Once manufacturing projects were registered, their factors were compared to identify common factors among the group of manufacturing projects, in Section 4.1.1.4. It aimed to retrofit and recompose the research model that presents relevant factors connecting collaboration and stakeholder management in industry 4.0 projects. Industry 4.0 projects taken place in different economy sectors were reported in subsection 4.1.1.5., because it is understood they may not be simply compared to manufacturing projects, as there may be sectorial diversity.

At last, preliminary research model was updated based on emergent factors for manufacturing industry 4.0 projects, as this research main contribution for theory, presented in Section 4.1.1.6. On the other hand, as a complimentary finding, similarities were identified on organization structures to handle industry 4.0 projects and initiatives. These reports were registered to highlight good managerial practices, shown in Section 4.1.1.7.

4 RESEARCH RESULTS AND DISCUSSIONS

This section discusses research results, organized in seven subsections. The first subsection registers research findings on industry 4.0 projects from a broader perspective, while the second subsection describes reported industry 4.0 projects with their associated key stakeholders. Following, the third subsection registers factors connecting collaboration to stakeholder management in each industry 4.0 manufacturing projects separately. While the fourth subsection compares these factors among the group of manufacturing projects.

The fifth subsection registers factors connecting collaboration to stakeholder management in each reported industry 4.0 project taken place in different sectors, other than manufacturing. Then, to summarize academic findings, the sixth subsection presents the final empirical research model, while the seventh subsection describes similarities in organization structures interviewed companies have adopted to cater for industry 4.0 projects.

4.1.1.1 INDUSTRY 4.0 PROJECTS

Industry 4.0 is recognized by academics and practitioners with a range of synonyms. In this context, Interviewee 3 highlights industry 4.0 may be called smart manufacturing, *industrie 4.0*, intelligent manufacturing, digital manufacturing, digital transformation, digitalization. Concurrently, interviewed academics and practitioners refer to industry 4.0 projects as digital projects, digitalization projects, or just 4.0 projects. Hence, all these synonyms may come up whenever an interview fragment is highlighted throughout next sections, as exemplified in Frame 8.

Interview	Industry 4.0 synonym	Interview fragment
I2	Digital transformation / Digitalization	"[…] we have the Digital Transformation Team, which is the most strategic unit of the company in the digitalization area."
I3	List of synonyms	"[..] There are countries that call smart manufacturing, *industrie* 4.0. […] [...] Some say that industry 4.0 can also be called intelligent manufacturing, digital manufacturing, digital transformation."
I4	4.0	"[…] When Sigma started working with 4.0 a few years ago, a decision was taken by the company's board […]"
I7	Digitalization	"The main feature of digitalization or industry 4.0 relates to the ability to reproduce small projects […]"
I9	Digitalization	"[…] I am responsible for digitalization of Sigma's agricultural products which we call agriculture 4.0."
I10	Digital	"[…] is project of our commercial area, but that also involves industry 4.0, or digital technologies. […]"
I11	Digitalization	"[…] Digitalization is much more complex, and it will in fact add value to manufacturing."

Frame 8: Synonyms for industry 4.0

Source: elaborated by the author

Supported by disruptive or exponential technologies, industry 4.0 projects must aim at business improvement, such as product customization, faster decision making, improved efficiency, as well as intra and interorganizational integration. Frame 9 presents perceptions of interviewees regarding this context. They are consistent with previous literature, for example with Lasi et al. (2014), that determine industry 4.0 is guided by two forces, pushed by technologies and pulled by transformations in businesses and markets.

ID	Academic / Practitioner	Disruptive technologies	Business transformation	
I1	Academic	"[…] industry 4.0 is very much guided by the disruptive technologies that have been stronger on the market more recently."	Intra and interorganizational integration	"[…] it naturally follows the design principles of industry 4.0: interoperability, transparency, horizontal and vertical integration."
I3	Academic	"[…] IoT, cloud computing and big data that are more recurrent (technologies)"	Improved manufacturing efficiency	"[…] We need management intelligence, to propose new models and new technological products that will contribute to both, manufacturing and other sectors."
I9		"[…] for me this is a great context in which there are exponential technologies […]" "When we go to 4.0, we talk about other technologies, we talk about big data, artificial intelligence, the internet of things with sensors."	Product customization	"[…] and increasingly empowered consumers, to generate insights and produce on demand."
I10		"[…] we presented the projects we have for cobots, collaborative robots, along with all the AGVs (Automated Guided Vehicles)." '[…] Our car exit process was entirely manual. […] […] We started thinking about RFID (Radio-Frequency Identification) […]"	Improved manufacturing efficiency	"[…] And what type of management gains will be generated? We will have information about which stations call most frequently, those who call more for quality problems, and those who call more for parts problem. […] […] we will have more and more data to improve performance and trigger changes. […]"

Frame 9: Disruptive technologies and business transformations of industry 4

Source: elaborated by the author

In-depth interviews corroborated industry 4.0 projects are supported by disruptive technologies. While an academic expert confirms this affirmative, another specifies technologies like IoT, cloud computing and big data are most commonly seen in industry 4.0 applications. Turning to practitioners, the same understanding exists. While a professional from an automotive manufacture reports on a wide range of technologies implemented to reach end-to-end industry 4.0, a professional from a chemical manufacture recognizes there are exponential technologies.

However, the same professional recognizes technologies are paired with empowered consumers, to enable manufactures to uncover insights, customize products, and improve efficiency. Academics also mention industry 4.0 supports business transformations. Among others, they highlight business integration, as well as new products and business models that could be engineered.

Various examples of industry 4.0 projects were reported during interviews. Considering that smart products and manufacturing projects may be evaluated in terms of their capacity to: monitor, control, optimize and provide autonomy (Moeuf et al., 2018; Porter & Heppelmann, 2014), progressively listed from low to high maturity projects (Porter & Heppelmann, 2014). Frame 10 presents fifteen industry 4.0 projects reported on interviews, classifying them on their capacity according to Moeuf et al. (2018), and Porter and Heppelmann (2014), on a systematic manner.

ID	Manufacturing / Other sectors	Project capacity	Technology	Project industry 4.0
I1	Manufacturing	Monitoring	Cloud computing	**Central ERP -** Factory equipment and instrument were connected to a central ERP that would send alerts and information to management team cell phones.
I2	Manufacturing	Optimization	Cloud computing, IoT, big data and artificial intelligence	**Smart Elevator -** Smart elevators offered to manufacturing costumers as a new business model, targeting predictive maintenance.
I3	Manufacturing	Monitoring	Cloud computing, IoT, big data	**Spindle -** Rotating equipment, so called spindle, is monitored on a research project that gathers data and aims at future predictive maintenance application.
I3	Other sectors	Control	Simulation of interconnected machines and Collaborative robots	**Physical and Virtual Laboratory –** A University lab developed to put students in contact with industry4.0 technologies and facilitate collaborative research with private companies.
I4	Manufacturing	Control	Cloud computing, IoT, big data	**Tablets for Maintenance -** Use of tablets for security rounds, work permits and preventive maintenance.
I4	Manufacturing	Monitoring	Cloud computing, IoT	**Drones for Inspection -** Use of drones for internal inspection of equipment.
I4	Manufacturing	Monitoring	Cloud computing, IoT	**Virtual Assistance with Smart Glasses -** Use of smart glasses or hollow glasses by production workers to enable documents consultation and virtual assistance by experts.
I5	Manufacturing	Monitoring	big data, artificial intelligence	**Smart NPS Feedbacks -** Analyze customers NPS (Net Promoter Score) assessment from dealerships to extract positive and negative comments from unstructured feedbacks to direct to specific manufacturing teams
I5	Other sectors	Optimization	Artificial intelligence	**Used Based Insurance –** Innovative insurance policy that offers discounts to users with lighter usage levels.

ID	Manufacturing / Other sectors	Project capacity	Technology	Project industry 4.0
I6	Other sectors	Monitoring	IoT	**Digital Onsite Inspection -** Implement a mobile solution to digitalize onsite construction inspections and improve information flow to external clients.
I8	Other sectors	Control	Cloud computing, IoT, RFID, collaborative robots	**Carnival 4.0 -** Organize a Carnival 4.0, having collaborative robots on the samba drome, members monitored by RFID bracelets and samba floats design aided by augmented reality.
I9	Manufacturing	Optimization	Cloud computing, big data, artificial intelligence	**Smart Field Manager –** Direct chemicals usage on farms considering satellite images processed by artificial intelligence solution.
I10	Manufacturing	Monitoring	Cloud computing, IoT, big data	**Connected Production Supervisor –** Tablets for production supervisor assisting on quality checks, production reports and training.
I10	Manufacturing	Control	Automated guided vehicles	**Automated Guided Vehicles –** Collaborative robot used to move parts to operators
I10	Manufacturing	Control	Cloud computing, IoT, RFID,	**Smart Outbound Logistics –** Outbound logistics was digitalized, identifying cars by an RFID tag. The project integrated operations with logistics partners.

Frame 10: Capacity and technologies of industry4.0 projects

Source: elaborated by the author

Besides, Frame 10 differentiates manufacturing projects from projects taken pace in other sectors and highlights which technologies were employed in each project. Valid to note projects that were not sufficiently detailed during interviews in terms of employed technologies and applications are not listed in Frame 10.

In this context, almost half of reported examples were monitoring projects, spanning from sensors to send alerts and information to managers´ cell phones to projects in which monitoring is clearly a step towards control and optimization. As an example, the research project in which data from rotating equipment, so called a spindle, is being gathered through IoT to support future predictive maintenance. Following, fragments of interviews are presented to characterize monitoring projects that were reported.

> "[…] All machines were connected to a central system, to a central ERP, which would send information to managers cell phones: […]"
>
> (Interview 1)

"[…] In the assembled IoT system, the tension pole monitors and sends data to a module, which conveys them to the cloud, where the application can anchor thousands of machines spread across the world. Each machine is coupled with a system that monitors the level of failure, to analyze if the equipment shows signs of wear. Thus, this is predictive maintenance, it is when the piece is used up to its limits. […]

(Interview 3)

"[…] Another technology we have used a lot is drones for equipment inspection. […]"

(Interview 4)

"[…] Another thing that it is under development and tests is the use of hollow lenses, which is a type of glasses, like in the minority report movie […] […] We could have a specialist anywhere in the world, and someone on the field, through the glasses, could access the specialist for him to see what is going on with the equipment or the manufacturing plant, and give instructions. […]"

(Interview 4)

"[…] It measures how much you liked a service […] […] the initial idea was to take the assessment that was unstructured text […] […] we would put intelligence to get a computer read it instead of people. […]"

(Interview 5)

"[…] we had a well dispersed team, and combining information was a huge bottleneck. Thus, […] […] this project of ours came to introduce a digital solution, which consisted of a mobile. […]"

(Interview 6)

"[…] Alpha, which is how we call the connected chief of unit. […] […] The chief of unity is in fact a production supervisor. Nowadays he has a tablet in his hands and all the information he needs is inside this tablet. He

> has information on how many cars he produces, and the quality defects he has. He must do what we call work post verification. […]”
>
> (Interview 10)

Complementing, a third of reported projects allow for control. They range from tablets employed on preventive maintenance in a chemical factory to logistics integration of cars produced and shipped to different locations. One of the interviewees reported on a singular project that intended to take industry 4.0 concepts to Brazilian Carnival, which assembled a variety of applications. Among them, they had a collaborative robot delivering drumsticks to samba musicians on the samba drome. Following, fragments of interviews are presented to enrichen characterization of reported projects.

> “[…] Another way to work with tablets is for preventive maintenance and production stops. […] […] Thus, with the tablet in the field, and using QR Code we may access equipment data. For example, when was the last time a maintenance check was run, what was the type of problem registered, we may also take a photo and file it, you may access the P&ID to check technical data about the production line, and technical data about equipment. […]”
>
> (Interview 4)

> “[…] one day in the end of December 2018, we were wondering how we could bring industry 4.0 into our daily lives […] […] Then we made a carnival 4.0. […] […] We had a robot delivering drumsticks to the members of the band. […]”
>
> (Interview 8)

Considering the SRL (Section 3.1) indicated research on capabilities and project management was in its initial phases, it was a surprise to identify three optimization applications among reported projects. Coincidently, two optimization projects implement new servitization business models, in which manufactures are coupling digital services to their products. The third project proposes discounts on insurance policies based on users' behavior. Following, reported fragments describe these projects.

> "[…] BETA is nothing more than a computing board that we install in the elevators, it continuously captures signals, which are sent to a gigantic database, which are our clouds. There are algorithms that, according to the processing, will trigger actions, be it corrective, preventive, or even predictive […]"
>
> (Interview 2)

> "[…] It is an UBI insurance policy […] […] we use artificial intelligence to do all the pricing based on data we have on each customer's behavior. […]"
>
> (Interview 5)

> "[…] At Omicron one of the modules manages the fields. What does it do? It helps producers to apply chemicals locally, where the problem is, and not across all the farm as it is normally done. For them to apply the product only where the problem is, the farm is read by satellite, information is stored, artificial intelligence translates information from satellite images, and generates an application map that is placed on machinery to be followed, to apply products only where the problems are. […]"
>
> (Interview 9)

Considering no projects aiming manufacturing autonomy were reported, and many reported projects are still focused on monitoring applications, findings indicate industry 4.0 projects are still on their initial stages. However, reported optimization projects were coincidentally directed to offer customers an innovative product.

Hence, this indicates opportunities to deepen industry 4.0 developments might lie on new business models connecting consumers and manufactures. This indication is supported by previous authors findings that claim industry 4.0 benefits are deepened with digitalized and collaborative business models (Agostini & Nosella, 2019; Garcia-Muiña et al., 2019; Lerch & Gotsch, 2015; Parida & Wincent, 2019; Qu et al., 2019).

On a different perspective, optimization projects show data transformed into information to be sold as a service to manufacturing costumers. Interviews also report industry 4.0 projects are not detached from data management. On the contrary, generation of data, information and intelligence differentiates automation and industry 4.0 projects. In this context, Frame 11 exemplifies how interviewees refer to data.

Interview	Data in Industry 4.0 Projects
I2	"[…] BETA is nothing more than a computing board that we install in the elevators and continuously capture signals, which are sent to a gigantic database, which are our clouds. […]"
I3	"[…] This way we can use data and create an algorithm to bring intelligence to this system. For now, we are just monitoring, bringing data in, so that the maintenance manager can trust the intelligence to define machines shall stop when they are close to the stress point. […]"
I4	"[…] Let us take the tablets' example, with which we may monitor rotating equipment. For example, we do vibration analysis. […] […] with this type of online data collection, with sensors and through the tablet, we may predict the MTBF, or Minimum Time Between Failure - of the equipment, and anticipate […] […] preventive maintenance. […]"
I5	"[…] In fact, we use artificial intelligence to do all the pricing based on data we have on customer's behavior. […]"
I7	"[…] Through this interconnection, the objective is to collect data for analysis and decision making, […]"
I9	"[…] Everything that happens on the farm generates data, for example, soil characteristics, climate, the region where the farmer is located. […] […] With all this information we can recommend to the farmer […] […] What seed is best for planting, what fertilizer is best to use, the best chemical, the best time to harvest […]"
I10	"[…] When you put a robot to do an operation, […] […] you have a repetitive operation that is doing the same thing all the time. Industry 4.0 adds the value of information on top of that. […] […] when we say a project is a digital one, it involves data, […]"
I11	"[…] This manufacture can then be closer to its goal, […] […] to have its production process more efficient, pull large amounts of data to understand what is happening with the production process in real time […] […] you have to know how to process and transform it into pertinent information, […]"

Frame 11: The role of data in industry 4.0 projects

Source: elaborated by the author

Industry 4.0, digitalization, or digital projects are still in its initial phases. However, it seems to be gaining momentum, especially on applications that comprise new business models offering digital products to manufacturing consumers. In this context, industry 4.0 projects must be data centered, aiming to turn data into information and business value.

4.1.1.2 REPORTED INDUSTRY 4.0 PROJECTS AND THEIR STAKEHOLDERS

Interviews have characterized various types of stakeholders across ten reported projects. Considering some projects reported on Frame 10 did not completely characterize project stakeholders, they are not listed in Frame 12. In this context, each industry 4.0 project and its associated stakeholders are classified, and manufacturing projects are differentiated from industry 4.0 projects held in other sectors.

Interview	Industry 4.0 Project	Manufacturing / Other sectors	Key stakeholders
I1	Central ERP.	Manufacturing	Project implemented by IT and Maintenance Teams, having the Manufacturing Team as internal clients.
I2	Smart Elevators	Manufacturing	Worldwide project implemented by Regional project team (Latin America) and CEO Latin America, guided by Central digital transformation team (Germany), and supported by Development team (Spain). Two partners worldwide. Gama transmits data from devices to the clouds, while Kappa stores information online and was decisive to develop application algorithms. Also, external customers to whom product is sold.
I3	Physical and Virtual Laboratory	Other sectors	The University Rectory, Professors from different area of knowledge and students. Partner Universities, Students from other universities, Private companies, and Sector Association of companies.
I4	Tablets for Maintenance	Manufacturing	Worldwide project implemented by Regional project team (North America), having the Factory Manager, as well as Maintenance and Operations Teams as internal clients. Guided by Central 4.0 Team, and Regional 4.0 Experts.
I5	Smart NPS Feedbacks	Manufacturing	Pilot implemented by IT Team, having NPS Team as internal client. Also affects Sales and Other Internal Product Teams.
I6	Digital Onsite Inspection	Other sectors	Project implemented by an Organizational Unit responsible for process improvements across the company, having inspection crews as internal clients. A partner Startup developed the mobile and software solution, together with the Process Improvement Team. External clients hiring Iota to monitor construction work on their behalf are also affected by the transformations introduced.
I8	Carnival 4.0	Other sectors	Project implemented by a group of Professors, having samba school President and Carnival Master as clients. Partnership with a number of Technology Companies and Universities to implement each feature.
I9	Smart Field Manager	Manufacturing	Worldwide project implemented by Regional Agriculture 4.0 Team for Latin America, guided by Central Agriculture Team. External customers to whom the product is sold.
I10	Connected Production Supervisor	Manufacturing	Worldwide project implemented by Digital Regional Team for Latin America with support from IT Team, having as a client the Factory Manager and Production Supervisors.
I10	Smart Outbound Logistics	Manufacturing	Project implemented by Industry 4.0 Logistics Team for Latin America, with support from IT and Digital Teams. Two logistics partners: One manages and storages cars prior to sales, and The Other transports cars to dealerships. Besides, The Port was also integrated when accepting cars for shipping.

Frame 12: Industry 4.0 Projects and Key stakeholders

Source: elaborated by the author

Following, manufacturing projects and projects held in other sectors will be analyzed separately. Priorly, as Frame 12 presents seven manufacturing projects, their practices are further characterized on subsection 3 of research results. This allows manufacturing projects to be compared, on section 4 of research results, considered they might present similarities.

4.1.1.3 COLLABORATIVE FACTORS IN MANUFACTURING PROJECTS

Factors connecting collaboration and stakeholder management are presented for each industry 4.0 project taken place in manufactures. Manufacturing project span from operation and maintenance improvements (3), through to new digital products being offered on servitized business models (2). Besides, a project presents digital integration of supply chain with connected logistics operators (1). Moreover, another project describes a pilot to digitally analyze feedbacks from manufacturing customers (1).

Based on preliminary research model (Figure 8), fragments of interviews are presented. As such, each project is characterized by speeches regarding definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012), information exchange (Brunet & Forgues, 2019; Liu et al., 2019), and trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012). Moreover, other emergent factors that might influence collaboration and stakeholder management are also highlighted.

4.1.1.3.1 CENTRAL ERP PROJECT

Frame 13 describes factors connecting collaboration and stakeholder management for the Central ERP Project, from the perspective of Interviewee 1. The project handles operations and maintenance improvements, with objectives established by top management and aligned with company strategy. Although, Interviewee 1 does not mention if these definitions were shared with the project team.

Reported Factors	Fragment of interviewee speech
Definition of project objectives	"[…] The objectives of the project were born from the strategic objectives of the company itself, that was to enter digital transformation. […] […] as the company has a lot of controls over equipment and machinery efficiency, O&E, the first thing that came up was to start having this. […]"
Top management support	"[…] kind of top to bottom project. […]"
Information exchange	"[…] The project had meetings, I think biweekly or monthly. […] […] to do follow-up, to see what needed top management support and so on. […]"
Joint problem solving	"[…] (solving problems) First maintenance and IT personnel would do everything possible within their operating radius. Eventually, when they encountered equipment that, for example, had no electronic capacity to support the new system, then the decision was escalated. […] […] discussions were supposed to happen in the follow up meetings. […]"
Joint problem solving	[…] Organizing things in the "kitchen" is more difficult […]"
Learning mindset	"[…] there were several problems... Because people who were implementing this installation were learning. […]"
Trust relationships	"[…] the working group knew each other from other projects, so probably older intrigues and disagreements eventually broke out in these biweekly meetings, but they were not necessarily generated by the problems discussed at the meeting. […]"
Different organizational cultures	"[…] in the moment you have an interdisciplinary team, better, a multidisciplinary team, that eventually is not formed only by members of the same company, because there may be a computing supplier, or there may be another supplier that will install the electronic circuit, naturally, collaboration within the team has to be more intense. […]"
Different organizational cultures	"[…] Eventually, the projects will be implemented by a group with different profiles, shaped by different organizational cultures. There are different companies, so there will be different cultures within the same team. […]"
Collaboration	"[…] Then collaboration is vital, right. […]
Leadership Coordination	"[…] It is part of the leadership role to mediate these relationships and to get the best out of everyone […]"

Frame 13: Collaborative factors of the Central ERP Project

Source: elaborated by the author

Regarding problem solving, it was clear multidisciplinary project team engaged to solve issues. While issues needing support from top management were discussed on frequent follow-up meetings. When asked about trust relationships, Interviewee 1 reported about long-term relationships among the project team, he / she also referred to conflicts and disagreements among them.

Interviewee 1 emphasized the role of management to overcome conflicts and coordinate activities. Also, he / she highlighted learning mindset was relevant to deal with equipment from different manufacturers and different versions, while attempting to connect them to a Central ERP. Considering project team is multidisciplinary, sometimes comprising external suppliers, Interviewee 1 believes collaboration is vital.

4.1.1.3.2 SMART ELEVATORS PROJECT

As a project that offers digital products to manufacturing customers, the Smart Elevators Project is detailed in Frame 14, from the perspective of Interviewee 2. In this context, objectives of Smart Elevators Project are compromised with the Central Digital Transformation Team, in Germany. As they are discussed in monthly meetings, it seems they are shared by project stakeholders. However, it was not clear if external companies, which are partners in the project, are as much aligned with project objectives.

Reported Factors	Fragment of interviewee speech
Definition of shared goals	"[…] we have a business case that is compromised with Germany, where we have our guidelines for up to 10 years. […]"
Joint problem solving	"[…] We also have weekly meetings with the Digital Transformation Team to deal with low level issues, daily actions we are taking to improve the processes and everything. […]"
Joint problem solving	"[…] Usually, when there is a problem that is more technical, we always need their support (Development Team) with our IT, our information technology. So, this exchange, this dynamic between the two happens a lot when we have a problem, especially at a low level. […]"
Joint problem solving	"[…] in this monthly […] […] status alignment meeting, we organize a slide to talk about the five main risks we are experiencing. So if we see that a risk is a highly complex one, that we cannot find solutions, or that the solution is complex, we take it there, because it may be that other countries are going through the same situation. […]"
Information exchange	"[…] in addition, we have the status alignment meeting, which is a monthly meeting with all countries and with the Digital Transformation Team to talk about the progress in each country […]"
Trust relationships	"[…] We first try to be a partner of our partners, that is exactly the phrase, partners of our partners. So, really work collaboratively […]"
Trust relationships	"[…] Talk about what happened, about what will come. And then we can have this relationship of trust a little tighter. We know who we are dealing with, it is not just about email and calls. […]"
Informal social interactions	"[…] We even have annual meetings, quarterly in fact, to get to know the technical and managerial level. So, once or twice a year, we go to the United States, or Germany, to talk to our partners. People come from Gama, people come from Kappa, just to talk about the project. […]"
Long-term relationship	"[…] we ended up building a very strong relationship of trust, including with our partners […] […] And we do not have a high turnover, so we have been able to work with the same people since the beginning of the project […] […] this relationship has consolidated and increased over time, […]"
End-users centrality	"[…] Another thing is having a customer complaining with me, because the moment the customer is complaining with me, it is no longer my problem, the problem is the customer's. […]"

Frame 14: Collaborative factors of the Smart Elevators Project

Source: elaborated by the author

Regarding problem solving, multidisciplinary project team engaged to solve intercurrences, while issues that needed support from top management were raised on frequent follow-up meetings. When asked about trust relationships, Interviewee 2 reported informal social interactions among project stakeholders facilitated the establishment of trust relationships. Also, long-term relationships have contributed to promote trust among stakeholders, as they have been working together for about 2 years. Summarizing, Interviewee 2 states they try to be "partners of their partners", and really work collaboratively.

4.1.1.3.3 TABLETS FOR MAINTENANCE PROJECT

The Tablets for Maintenance Project is another example of a project focused on operations and maintenance improvements (Frame 15), described from the perspective of Interviewee 4. In this context, project objectives were jointly discussed. They were defined bottom up by a multidisciplinary team, comprising people from different functional teams: plant management, project management, maintenance, operations, and central industry 4.0 team.

Reported factors	Fragment of interviewee speech
Definition of shared goals	"[…] (definition of project goals) the person responsible for the plant, an engineer or project manager invariably participates. In this case, for the tablets, we had a person from reliability and maintenance, we had an operations person and a person from the central unit, who had developed the tablet in another plant and would help with implementation of the tool. […]"
Definition of shared goals	"[…] For these projects, the definitions were made mostly bottom up. Depending on the situation or the initiative, I could make it clear, from the start, what my expectations are, […] […] because it is new technology and we are not sure, so I let the team work and make a proposal […]"
Joint problem solving	"[…] whenever we talk about a 4.0 project, we work in partnership with these people (Industry 4.0 Central Team and Regional 4.0 Experts). […] […] Sigma works with a roll out model, in which we implement pilot tools in plants around the world, and then we learn from those pilots to roll them out […]"
Joint problem solving	"[…] when dealing with new technologies and projects, there may be an urgency along the way […] […] You may need approval from the steering committee to eventually change scope or increase cost, and you cannot wait a month. Thus, we call an extraordinary meeting. […]"
Joint problem solving	"[…] I believe there is great exchange, not only of successes, but also of setbacks, but with a very positive focus. […] […] we implemented it in a plant x, which may have been in Asia, and those were the difficulties, so when you are going to implement this in your plant in North America, this is what we saw as difficulties and this is what we implemented to improve it. But see how this model works in your plant and then share with us what the lessons learned were. Thus, as we have this contact via Region with this group of specialists, there is a very constant exchange among the regions. […]"
End-users centrality	"[…] There are a lot of people involved, but the main piece for me are the users themselves, […] […] there are still solutions being launched and improved without having much opinion from those who will use the solutions, from the beginning. I see that this is changing at Sigma, and this is one of the great drivers for working with pilots. […]"

Reported factors	Fragment of interviewee speech
Learning mindset	"[…] And to be very honest, fulfilling the objective or not is not what really matters, because it is still learning, and we own these tools. I know that we will benefit, but the number for me, whether it will be 10, 20 or 30 is not so relevant right now. […]"
Learning mindset	"[…] Not everything will work out, but everything is learning, since you at least know how it works, you know how you could improve it. Maybe you test the tool for one application, and it does not seem to work, but it might work for another application. […]"
Trust relationships	"[…] There must be good alignment between the people who approve, and when you expand it outside the department itself, outside manufacturing, or outside the company, people must be well aligned as to what the expected benefits are […]"
Trust relationships	"[…] Trust is important and fundamental in the projects we work on, at any level. Whether it is in the context of the project team, the way the scope is developed, the way the team will work, because things may go wrong. […]"
Trust relationships	"[…] as we have a culture that values growth, if something goes wrong people do not want to find someone to blame, but focus on the problem, to solve it and then learn from it. Okay, that is what happened, but it will not happen again. […]"
Top management support	"[…] I see an evolution in recent years and interest is growing. And I see more money available to work with automation and operational excellence, for the last 3 or 4 years. So, I believe we are on the right path. I see support and interest from the company's Board to make this really work. […]"
Information exchange	"[…] The project team, for example, for those who are in the plant and are in the ideation and implementation phase, is frequently (information exchange), every day, to develop the project. […]
Information exchange	"[…] as the hierarchy goes up, this interaction is less frequent. So, […] […] when we think about the steering committee, they meet once a month to monitor the projects. And the idea of monitoring is to see how things are going and to see what other support the team needs for implementation. […]"
Stakeholders identification and assessment	"[…] Inside the company, depending on the people you have or not on the team, and who you have participating in the decision-making process, you use more charm or less, to persuade them and get things approved. Because not everyone thinks the same way, obviously. There are people who support more and people who support less. […]"
Long-term Relationship	"[…] our relationship with Germany is very good. It has evolved considerably in the last 17 years, and as everything has its positive and negative points. […]"
Win-win solutions	"[…] the mixture of cultures is what is interesting, you must use the positive aspects of each one. And they are very structured, very well organized, they plan very well, so I think they bring a bit of this mentality to other teams. […]"

Frame 15: Collaborative factors of the Tablets for Maintenance Project

Source: elaborated by the author

Regarding information exchange, project team interacts daily to develop the project, and, as the hierarchy goes up, the company relies on frequent follow up meetings to monitor the project and verify other support project teams might need. When solving problems, the presence of a Central Industry 4.0 Team is highlighted. They share their experience from other plants and are opened to listen about lessons learnt in each project.

Referring to trust, Interviewee 4 emphasized their organizational culture values problem solving and learning with setbacks, as a way to improve knowledge and refrain similar occurrences in the future. Besides, alignment among top management about expected benefits was also pinpointed. On a different perspective, learning mindset was highlighted as relevant in industry 4.0 projects, as experimentation enables organizations to get used to new technologies. In this context, pilot implementation and involving end-users facilitate developments.

Interviewee 4 describes different approaches to convince stakeholders who might support more or less the project. Through theory light, this could be seen as stakeholders identification and assessment, to select adequate engagement practices (Eskerod et al., 2015; PMI, 2017). Also, he / she describes how his / her relationship with partners from central management has evolved over time. On the other hand, leadership coordination might enable supplementation of capabilities within a multicultural team. Finally, and from a broader perspective, interview 4 reports increased company support for industry 4.0 projects, as well as automation and operational excellence for the last 3 or 4 years.

4.1.1.3.4 SMART NPS FEEDBACK PROJECT

The next project is a pilot to evaluate feedbacks from manufacturing costumers employing artificial intelligence. Frame 16 details factors connecting collaboration and stakeholder management for the Smart NPS Feedbacks Project from the perspective of Interviewee 5. It was an embryonic project, proposed by an innovation team, that unfortunately did not go through.

Reported factors	Fragment of interviewee speech
Lack of effective Stakeholders identification and assessment	"[…] I might advance and say the project went bankrupt because of the stakeholders. […]
Lack of effective Stakeholders identification and assessment	"[…] The stakeholders were the young lady at the dealership who would take the photo, the NPS assessment team that managed the assessment, and the technology team that was involved, we also involved an information security person and an innovation technology supervisor, and myself […] "
	"[…] (sales executives) they could tell a good dealership from a bad one. The process was valuable, but it was possible to be explored further. […] […] Bad dealerships had attention and received visits to understand what was happening. […] […] All dealerships had their own NPS grading, so the sales executive had access to the grades of their dealerships. […]"
Lack of effective Stakeholders identification and assessment	"[…] The idea was to direct these assessments, these problems. […] […] Supposing that we had 10 shock absorber assessments with negative score, then we would take it to the shock absorber team and say there was a problem with the product. […]"
Lack of shared goals definition	"[…] Other executives' opinion mattered a lot, because we were going to mess with people from other areas, and thus the project went bankrupt. […]
Lack of shared goals definition	"[…] (stakeholder engagement) We tried to show the value of the project upwards. including financial value. Thus, we run financial calculations of how much it could save on people, based on staff reduction. […]"
Lack of shared goals definition	"[…] the value was calculated, and Upsilon knew that dealer X was selling very well because customers liked the service a lot. […] […] but the feedbacks were left in limbo. […] […] for example, dealerships that were halfway there, which were neither good nor bad, they had no attention at all. […]"
Lack of shared goals definition	"[…] Another thing is that they could not understand easily what the benefits in terms of personnel reduction were, because they were attached to each person's position. […]"
Learning mindset	"[…] it was performed within the center of excellence for project management, but it was a very embryonic project. It was a test that we were doing. […]"
Lack of a digital mindset	"[…] we saw that in these bases from China there was no data regarding NPS review from people who bought cars. Thus, we started this initiative […] […] And we went to try get sponsorship so we could get of this data. […]"
Joint problem solving	"[…] And we went to try get sponsorship so we could get this data. So, it was a long way to find out where data from dealerships was stored, map the entire process flow, talk to the dealership guys to ask them […] […] to send us the data. […]"
Lack of top management support	"[…] our idea was based on this unstructured text. We would put intelligence to get a computer read it instead of people. We could replace an entire team for a computer, […] […] That was the idea. However, it did not go forward for political reasons, but it does not mean the algorithm did not work. […]
Lack of top management support	"[…] what we had was top management, except that top management, for cultural reasons from Upsilon, are not necessarily aligned with other top management. […]
Lack of effective project sponsoring	"[…] We found this innovation supervisor who sponsored the idea, but he did not sponsor it very well. He sponsored it like that, I believe it is cool, but if someone squeezes me, I will not defend it much. […] […] He was from tech. […]"

Frame 16: Collaborative factors of the Smart NPS Feedbacks Project

Source: elaborated by the author

It seems stakeholders' identification was not as effective as it could have been for the reported project, leading to complications ahead. As the project directly affected NPS and Sales Teams, if they were involved to define project goals since the beginning, perhaps a more successful outcome would occur.

An executive from IT Team sponsored the project, but it appears he / she failed to convince other affected stakeholders about project benefits. Consequently, project did not gather comprehensive top management support to go ahead. In this context, a long and tortuous path is described since ideation to potential implementation. Interviewee 5 reports difficulties of an innovative project taken place in a company with poor digital mindset.

4.1.1.3.5 SMART FIELD MANAGER PROJECT

The next project offers digital services to agriculture customers, the Smart Field Manager Project (Frame 17), reported from the perspective of Interviewee 9. End-users are seen as main stakeholders from whom companies should gather information to develop industry 4.0 projects. However, currently, end-users are not as much involved to define project objectives as they should have been.

Reported factors	Fragment of interviewee speech
Definition of shared goals	"[…] when you ask me if the main stakeholders participate in the definition of objectives, for me the customer should be the stakeholder defining project objectives, and not internal stakeholders. […]"
End-users centrality	"[…] you must show the stakeholder each implemented version, mainly to customers, for them to give their feedback. You check if they like it or not, and you increment and improve the product according to continuous feedback from the main stakeholder, which is the customer. […]"
Stakeholders identification and assessment	"[…] (stakeholders) and of course, you need to identify supporters and detractors to know how to treat each one. […] [..] you identify the degree of influence and interest of each stakeholder in your project and based on this scale you define certain actions for each type of stakeholder you have. […]"
Information exchange	"[…] When we go to tactical, to project implementation, […] […] it is up to you being an evangelizer in the company, convincing people to experiment more, innovate more, do more tests. Thus, you break down barriers that may exist in terms of innovation. […]"
Information exchange	"[…] Well, this frequency depends on each of them. […] […] In general, I would say they are assessed at status meetings, where project progress is shared. […]"
Digital sponsor	"[…] first there is an educational part, because all this is very new, […] […] Thus, we need to educate the company about all these changes. Leaders dealing with digital transformation, or industry 4.0, are responsible for teaching the company how to operate now in this new economy […]"
Joint problem solving	"[…] Once you teach, you start to engage, […] […] you involve these stakeholders in the experiments you are running, you involve these people to understand in practice how these actions may bring benefits and results, and then projects are moved forward. […]" "[…] We invest a lot […] […]to engage stakeholders to participate in the project with us. […]"
Joint problem solving	"[…] When you work with digitalization projects you must be prepared for changes. Changes are welcome and add value to projects. We use agile methodologies because with them the project is alive, […] […] all the time things happening, and we keep improving it continuously […]"
Joint problem solving	"[…] And then there is this frequency, based on the day-to-day projects […]"
Training	"[…] We invest a lot in training, education […]"
Trust relationships	"[…] Trust is classic, you must have stakeholders who can bring you the right vision for you to follow. […] […] In my opinion, it is very different from holding meetings or committees, like traditional companies. In my view, it is necessary to create real problem-solving forums, with demonstration days for you to create this relationship with stakeholders. […]"

Frame 17: Collaborative factors of the Smart Field Manager Project

Source: elaborated by the author

Information exchange and training are seen as relevant steps to promote digitalization mindset in companies. In this context, experimentation is continuous, and customers are sources of innovation. Besides, digital sponsors might facilitate spreading the digitalization word. Referring to information exchange and problem solving, they are seen as day-to-day routine among the project team, while progress is timely shared with top management during status meetings. Interviewee 9 believes involving stakeholders with practice improves their engagement with project results.

When asked about trust relationships, he / she states events for joint problem solving are opportunities to build trust, even more than ordinary status report meetings. Once again, stakeholders identification and assessment is highlighted, to understand which stakeholders support and threaten the project, to adopt adequate engagement practices (Eskerod et al., 2015; PMI, 2017). Moreover, agile practices are brought up to handle all the changes industry 4.0 projects face, on dynamic digitalization environment. Each implemented version of the project must be verified by customers and end-users, to gather their feedback prior to further improvements.

4.1.1.3.6 CONNECTED PRODUCTION SUPERVISOR PROJECT

Two projects were reported by interviewees of one same company: Connected Production Supervisor and Smart Outbound Logistic. The first describes operations and maintenance improvements and the second supply chain integration. Therefore, speeches that were general and regarded the company's environment are duplicated on each project frame.

Focused on the Connected Production Supervisor Project, Frame 18 describes factors connecting collaboration and stakeholder management from the perspective of Interviewee 10A and 10B. Both interviewees have been working on industry 4.0 projects for a few years, despite not having hierarchical connection. Relevant to highlight, it was noticeable during interview how much their understanding is aligned.

Reported factors	**Fragment of interviewee speech**
Definition of shared goals	"[…] For us to get supervisors to work, we had to convince his boss to work as well, and their director. […]
Definition of shared goals	"[…] we did, in fact the corporate did, they did a whole survey of supervisors' time loss, while looking for paper, and all their movement. What we were looking for with this project was to increase supervisors' efficiency and we measured this efficiency by reducing quality problems, with productivity […]"
Top Management Support	"[…] But if you ask me how we did it, it was in fact by convincing the Manufacturing Vice President worldwide, because he supported it. […]"
Top Management Support	"[…] if you do not have the support of a high-level director, it is difficult for you to convince operations to apply and use it. […] […] even though I am a director, it is difficult for me to convince the factory to use a certain system. If the factory director does not buy it […]"
End-users' centrality	"[…] When the Connected Production Supervisor arrived, we had some connection difficulties, staff engagement as well. Imagine, these supervisors worked with paper, paper notebooks, and suddenly we give them a tablet. Thus, many supervisors were reluctant to use it. […]"

Reported factors	Fragment of interviewee speech
End-users' centrality	"[..] They started using it, and we developed a tool in which we knew the ones using it more, or using it less, we knew those with low adherence. We monitored it with great care, until we could engage them to use it. […]"
Learning mindset	"[…] We have learned a lot with this project. […]"
Joint problem solving	"[…] in Brazil we also started slowly with a few pilots until we could roll it out completely. First, we wanted to test it technically, then test with a few supervisors and then we did the total roll out. […]"
Joint problem solving	"[…] we had a lot of Wi-Fi problems. Sometimes supervisors wanted to load documentation and the network took long and long to do it. This is not 100% resolved yet, but it is already much better. We had dark areas inside the factory that IT had to deal with. IT is always close by, to work as a team. […]"
Information exchange	"[…] at the beginning there were weekly implementation meetings, with manufacturing, and IT. As the project evolved, conversations became daily. […]"
Training	[…] There was this discussion that supervisors change, and new ones must be trained. […]
Training	"[…] first, we delivered the tablets, and most supervisors did not even know how to open the tablets. Thus, we had to call them and train them to develop that. […]"
Digital sponsor	"[…] we have digital pilots in each area. This digital pilot, on my side I have a person from process, and in supply chain, for example, we have X who is the digital pilot there. And in each of these areas, we have an IT manager who works with us. […]"
Joint problem solving	"[…] sometimes he sees things and points out there are different ways to solve problems, with tools, in ways I never imagined. On the other hand, he sometimes comes to me and shows me there are a lot of information he does not know what to do with it, and I try to point out a direction. […]"
Joint problem solving	"[…] Thus, that is why we are well aligned, because we work very closely, very strongly. I tell Interviewee 10B that he is my right hand. Although I am manufacturing and he is IT, and we have no hierarchical connection, we are well aligned working together. […]"
Joint problem solving	"[…] we had some changes. Some time ago business came with an idea, and then IT analyzed it. Now IT is organized in a different way here because they want to be together with business to analyze opportunities with us and find opportunities to leverage our work a bit more. […]"
Long-term relationship	[…] We have aligned our views more after the Forum, when we worked together a lot […]
Digital mindset	"[…] (World Forum International auditing) In addition to the cases, they try to feel what the environment is inside the factory, if there is a real digital environment. They try to feel it. They ask questions and try seeing if that culture exists. […]"

Frame 18: Collaborative factors of the Connected Production Supervisor Project

Source: elaborated by the author

To define project goals and get it approved, Factory Team relied on Corporate Teams to estimate potential improvements to factory efficiency. Also, Factory Management had to be convinced about the benefits laying ahead. Regarding joint problem solving, pilot implementation was carefully planned to resolve technical problems, and then, with participation of a few supervisors, to resolve functional problems prior to roll out. Even though, technical, and cultural problems did occur.

Wi-Fi technical problems affected implementation. Despite, they were resolved together by Business and IT Teams. Another barrier was supervisors' resistance to adopt the new tool. Such resistance denotes end-users could have been better involved in project conception and development. To overcome resistance towards the tablet, supervisors were trained, and individual usage was monitored. Referring to the difficulties they had to transpose, Interviewee 10B understands they have learned a lot with the project.

Regarding information exchange, Interviewees 10A reports initial weekly meeting have turned daily on the heat of the project. Unfortunately, trust relationships were not discussed during interview, due to time constraint. Finally, convincing top management about project value was essential to facilitate inter department acceptance. Surpassing project borders, alignment among IT and Business departments is visible, as both interviewees report they work very closely together. There is an IT Person working closely to Digital sponsors to analyze opportunities and find solutions to leverage the business. They report one's expertise supplement the others' and vice versa.

4.1.1.3.7 SMART OUTBOUND LOGISTICS PROJECT

Still in the context of the same company in which the Connected Production Supervisor took place, next project handles interorganizational integration with logistics partners. In this context, Frame 19 describes factors connecting collaboration and stakeholder management for the Smart Outbound Logistics Project, from the perspectives of Interviewee 10A and 10B.

Reported factors	Fragment of interviewee speech
Definition of shared goals	"[…] First, our internal logistics operator had to agree with the project. There were a lot of negotiation and their contract had to be redone, because there was also reduction in their personnel, of their operation, […]"
Win-win solutions	"[…] Although it was very bad for us that a car that should have been in São Paulo was in Manaus or Recife, at the end of the day the cost was left to the logistics operator, because they were wrong on placing the car. Thus, they were also interested on developing and improving it. […]"
Definition of shared goals	"[…] Then, there were conversations and negotiations with the port to convince them to accept the project and show them the gains they could have as well. […]"
Win-win solutions	"[…] This was one of our largest gains because information on the products arriving at the port is sent from the factory. Thus, they already advance all clearance before the truck arrives. It has been well anticipated. As it is all done via system, I believe clearance is easier for them as well. […]"
Digital sponsor	"[…] we have digital pilots in each area. This digital pilot, on my side I have a person from process, and in supply chain, for example, we have X who is the digital pilot there. And in each of these areas, we have an IT manager who works with us. […]"
Joint problem solving	"[…] sometimes he sees things and points out there are different ways to solve problems, with tools, in ways I never imagined. On the other hand, he sometimes comes to me and shows me there are a lot of information he does not know what to do with it, and I try to point out a direction. […]"
Joint problem solving	"[…] Thus, that is why we are well aligned, because we work very closely, very strongly. I tell Interviewee 10B that he is my right hand. Although I am manufacturing and he is IT, and we have no hierarchical connection, we are well aligned working together. […]"
Joint problem solving	"[…] we had some changes, some time ago business came with an idea, and then IT analyzed it. Now, IT is organized in a different way here because they want to be together with business to analyze opportunities with us and find opportunities to leverage our work a bit more. […]"
Long-term relationship	[…] We have aligned our views more after the forum, when we worked together a lot […]
Digital mindset	"[…] (World Forum International auditing) In addition to the cases, they try to feel what the environment is inside the factory, if there is a real digital environment. They try to feel it. They ask questions and try seeing if that culture exists. […]"

Frame 19: Collaborative factors of the Smart Outbound Logistics Project

Source: elaborated by the author

For the Smart Outbound Logistics Project, definition of goals involved negotiation with at least three other companies: one managing cars on storage yard, another transporting them to dealerships and The Port that would dispatch cars to other countries. Interviewees report project has rendered benefits also for their partners, on a win-win solution. However, as the project manager was not present on interview, aspects of information exchange and trust relationships were not discussed.

Company has been recognized as an industry 4.0 lighthouse by the World Economic Forum and The McKinsey & Company (2019), thus digital mindset was verified during forum auditing. As another requirement for the recognition, they must show they have end-to-end solutions, which encompass many aspects of manufacturing, as well as other departments of the company.

4.1.1.4 COMPARING COLLABORATIVE FACTORS OF MANUFACTURING PROJECTS

Considering there may be some convergence among collaborative factors held in manufacturing projects, they are further compared. Eighteen factors were identified, organized on Frame 20 from the ones with more convergence downwards. In this context, each reported manufacturing project is marked to signal factors agreeing with literature (+) and those disagreeing (-). When factor was not mentioned on interview, its correspondent cell for the project was left blank.

Collaborative factors of Industry 4.0 Projects	Central ERP	Smart Elevators	Tablets for Maintenance	Smart NPS Feedbacks	Smart Field Manager	Connected Production Supervisor	Smart Outbound Logistics	Classification of Factors
Definition of shared goals	+	+	+	-	+	+	+	In Interview Protocol - Relevant
Joint problem solving	+	+	+	+	+	+	+	In Interview Protocol - Relevant
Information exchange	+	+	+		+	+		In Interview Protocol - Relevant
Top management support	+		+	-	+	+		Relevant
End-users’ centrality		+	+		+	+		Relevant
Learning mindset	+		+	+		+		Relevant
Long-term relationship		+	+			+	+	Relevant
Trust relationships	+	+	+		+			In Interview Protocol - Relevant
Digital mindset				-		+	+	To be analyzed in specific context
Digital sponsor					+	+	+	To be analyzed in specific context
Stakeholders identification and assessment			+	-	+			To be analyzed in specific context
Training					+	+		To be analyzed in specific context
Win-win solutions			+				+	To be analyzed in specific context
Different organizational cultures	+							To be analyzed in specific context
Informal social interactions		+						To be analyzed in specific context
Leadership Coordination	+							To be analyzed in specific context
Effective project sponsoring				-				To be analyzed in specific context

Frame 20: Comparing collaborative factors of Manufacturing Projects

Source: elaborated by the author

Preliminary research model listed definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012), information exchange (Brunet & Forgues, 2019; Liu et al., 2019) and establishment of trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012), as factors connecting collaboration and stakeholder management practices in industry 4.0 projects. Hence, these factors supported interview protocol.

This research understands these four factors are relevant to connect collaboration and stakeholder management, considered reported industry 4.0 projects. References to definition of shared goals and joint problem solving were identified in all seven manufacturing projects. Information exchange and trust relationships were not directly questioned in two and three interviews, respectively. Therefore, it could explain these factors not been mentioned across all seven studied manufacturing projects.

As a complimentary research finding, other factors not directly discussed on interview protocol were raised during empirical interventions. Mentioned on five and four projects out of seven manufacturing projects: Top management support, End-users' centrality, Learning mindset and Long-term relationship are considered relevant factors connecting collaboration and stakeholder management in industry 4.0 projects.

Analyzing each of these factors through literature light, industry 4.0 authors understand top management must be committed to change process (Agostini & Nosella, 2019; Rashid et al., 2018; Yadegaridehkordi et al., 2018). In literature about collaboration and stakeholder management, a reference to top management support highlights its lack as a barrier for collaborative projects (Mollaoglu et al., 2015). As such, this study considers top management support as a relevant factor connecting collaboration and stakeholder management in the studied manufacturing projects, in the context of industry 4.0.

Turning to end-users' centrality, previous industry 4.0 studies describe end-users must be involved in industry 4.0 initiatives (Campatelli et al., 2016; Dewa et al., 2018; Hannola et al., 2018; Salehi, 2020; Sjödin, 2019). While collaboration and stakeholder management literature argue stakeholders and customers must be involved early in the project lifecycle (Azhar et al., 2012; Serrador & Pinto, 2015).

As such, this study considers end-users' centrality as a relevant factor connecting collaboration and stakeholder management in the studied manufacturing projects, in the context of industry 4.0. Be these end-users' internal or external customers for the project. Valid to notice, though, this mindset centered on end-users' needs might not be entirely absorbed into organizational culture, as Interviewee 4 and 9 describe.

Regarding learning, industry 4.0 authors argue it accompanies industry 4.0 innovation (Hannola et al., 2018; Nikitina & Lapiņa, 2019). In this context, Nikitina and Lapina (2019), define industry 4.0 professionals must be committed to continuous learning (Nikitina & Lapiņa, 2019). Likewise collective learning is highlighted by authors writing about collaboration and stakeholder management (Couix & Hazard, 2013; Herazo & Lizarralde, 2015).

Interviews have shown studied manufactures regard industry 4.0 projects with a learning mindset, open for trial and error, as described in the Tablets for Maintenance and Central ERP Projects. This learning mindset is also discussed as a powerful tool for collective problem solving in industry 4.0 literature, when different interpretations challenge and refine ideas (Campatelli et al., 2016; Ratzmann et al., 2018; Salehi, 2020; Sjödin, 2019). As such, this study considers learning mindset as a relevant factor connecting collaboration and stakeholder management in the studied manufacturing projects, in the context of industry 4.0.

At last, long-term relationships are not discussed on literature about capabilities and project management in industry 4.0. However, in the context of collaboration and stakeholder management, long term relationships are seen as relevant to deepen relationships. Couix and Hazard (2013), for example, state stakeholders learn to work together along the practical journey, while Zuo et al. (2009), suggests good communication foster long-term relationships among stakeholders.

Moreover, teamwork is facilitated in project teams with previous working relationships (Senaratne & Sexton, 2004). As such, this study considers long-term relationship as a relevant factor connecting collaboration and stakeholder management in the studied manufacturing projects, in the context of industry 4.0.

Other six factors were mentioned in two or three out of seven manufacturing projects: Digital mindset, Digital sponsor, Stakeholders identification and assessment, Training, and Win-win solutions. They are considered leads for further investigation in specific contexts. Hence, each of them is specifically discussed.

Digital mindset comes up in two projects taken place in an automotive manufacture recognized by the World Economic Forum as an industry 4.0 lighthouse (World Economic Forum & The McKinsey & Company, 2018). Besides, lack of digital mindset was interpreted as a barrier for implementation of the Smart NPS Feedback Project, an innovative pilot project held in a more traditional automotive manufacture. As expected, digital mindset is a factor reported on companies with recognized high maturity in industry 4.0 projects. However, it is a construct yet to researched and better defined.

Digital sponsors are also raised in the same two projects taken place on the industry 4.0 lighthouse manufacture, Connected Production Supervisor and Smart

Outbound Logistics Projects. Besides, it is mentioned in the Smart Field Manager Project by an interviewer that specifically manages digital projects for the agriculture business of a worldwide chemical manufacture. These three contexts show high digital awareness, which could explain this innovative view. However, it is a construct yet to researched and better defined.

Stakeholders identification and assessment is a pilar of project stakeholder management (Bourne & Walker, 2008; PMI, 2017). Thus, it was expected to have been discussed by most manufacturing projects. However, that was not what happened, as only two projects referred to it specifically, Tablets for Maintenance and Smart Field Manager. In the third project, Smart NPS Project, identification and assessment of stakeholders could have been improved. Fragments of interview show sales executives, which were key stakeholders affected by the project, were not fully involved with decisions since the beginning.

Therefore, it seems most studied projects did not have a systematic process to identify and assess project stakeholders. Nevertheless, practices for collaboration and stakeholder engagement were identified, for example, definition of shared goals, joint problem solving, information exchange and trust relationships. Hence, further research could focus on understanding how industry 4.0 manufactures identify and assess project stakeholders.

Industry 4.0 literature alerts manufactures must invest on training their professionals (de Sousa Jabbour et al., 2018; Moeuf et al., 2019; Ooi et al., 2018; Singh et al., 2019). In the context of this research interviews, training was raised by two manufacturing projects: Smart Field Manager and Connected Production Supervisor. In one context as a way to previously engage stakeholders with digitalization projects and concepts, while in the other, training was provided to supervisors to counter act difficulties on tablets’ implementation. Hence, these two aspects of training could be further researched.

Win-win solutions are mentioned by Hasselblatt et al. (2018), when discussing end-users’ involvement in the context of industry 4.0 literature. Besides, they are targeted by collaborative stakeholder management, that recognizes stakeholders’ concerns and interests (Eskerod et al., 2015). On the interviews, they were mentioned by two projects: Tablets for Maintenance and Smart Outbound Logistics, when referring to inter department and interorganizational stakeholders. Thus, both contexts could be further researched.

Finally, some factors were only mentioned in one interview out of seven, which could reflect specific project environment and configuration. All of them have been previous mentioned on specialized literature: Different organizational cultures (Nijhuis et al., 2012), Informal social interactions (Soh et al., 2011), Leadership coordination (Bedwell et al., 2012), and Effective project sponsoring (Rashid et al., 2018). Again, they are worth further investigation.

4.1.1.5 COLLABORATIVE FACTORS OF PROJECTS FROM OTHER SECTORS

Factors connecting collaboration and stakeholder management in other sectors are described for each specific project. These projects span from a solution for digital onsite inspection, implemented by an engineering consultancy, through to a physical and virtual laboratory, implemented by a University, to allow collaboration among professors, students, and private companies. Besides, a group of professors organized a Brazilian carnival 4.0 intending to take industry 4.0 concepts closer to society.

4.1.1.5.1 PHYSICAL AND VIRTUAL LABORATORY PROJECT

Factors connecting collaboration and stakeholder management, for the Physical and Virtual Laboratory Project, were described in Frame 21, from the perspective of Interviewee 3. In this context, definition of project objectives is done collaboratively, be it with internal stakeholder affected by the new laboratory, or with private companies and sector associations research projects might be run together.

Reported factors	Key stakeholders
Definition of shared goals	“[…] My idea is to help the graduation director to restructure the engineering curricula, to form a different engineer, because the mechanical engineer who knows how to operates a lathe is long gone. The lathe will still exist, but it needs to be monitored by sensors and IoT, to generate data and artificial intelligence […]”
Definition of shared goals	“[…] Zeta wants […] […] co-mentoring, with the student in their company talking to us on behalf of the company. His project is related to a subject that Zeta needs understanding, and not on a subject that the researcher wants to study but has got no ties with the industry […]”
Joint problem solving	“[…] With Zeta, for example, we talk a lot about collaboration. Some software they use is in the virtual platform that we are installing. Then students could use the digital twin simulation, for example, to redesign a production line. […]”
Informal social interactions	“[…] this is also a challenge of mine. Getting closer to associations […]”
Win-win solutions	“[…] we must satisfy this future stakeholder, having the tools to bring us closer. […]”

Frame 21: Collaborative factors of the Physical and Virtual Laboratory Project

Source: elaborated by the author

When discussing collaboration with business sector, Interviewee 3 mentions his / her efforts to establish social interactions with a number of companies and associations. Companies wish to participate on research projects with University that aim at solving issues relevant for the business. On win-win partnerships each stakeholder collaborates to achieve mutual gains. Unfortunately, information exchange and trust relationships were not discussed during interview, due to time constraint. Frame 22 summarizes factors brough up on interview.

Highlighted factors	Physical and Virtual Laboratory
Definition of shared goals	+
Joint problem solving	+
Informal social interactions	+
Win-win solutions	+

Frame 22: Summary of factors - Physical and Virtual Laboratory Project

Source: elaborated by the author

Considered this project is an interorganizational project, its collaborative factors could be compared with other interorganizational manufacturing projects: the Smart Elevator and Smart Outbound Logistics Projects. Indeed, informal social interactions are highlighted on the Smart Elevator Project. Hence, influence of social interactions could be further researched in industry 4.0 projects connecting universities and the private sector.

4.1.1.5.2 DIGITAL ONLINE INSPECTION PROJECT

The next project comprises implementation of a digital solution to improve onsite inspection on an Engineering, Procurement and Construction Management (EPCM) company (Frame 23). Collaborative factors were described from the perspective of Interviewee 6. On a classic report of shared goals and end-users' centrality, definition of project goals was based on extensive interviews with external and internal clients. Onsite inspectors which were to use the mobile solution when implementation was concluded, were also heard during definition of project goals.

Reported factors	Key stakeholders
Definition of shared goals	"[…] there was a round of interviews with the most relevant customers, and internally as well […] […] as the idea was to expand this tool for company personnel, there were also several internal interviews […]"
Definition of shared goals	"[…] Our objectives were derived from these interviews we did to map what the platform needed to deliver. We extracted some objectives, some indicators to be mapped […]"
Definition of shared goals	"[…] On the client side, we also interviewed the strategic layer. They do not even have an operational structure, but a first-level management structure, that accompany the construction jobs at a bit more distance, but still do. So, the project circulated through these areas from our clients as well. […]"
Joint problem solving	"[…] the proposal for this solution that we implemented came from a partnership with a startup that already operated in inspections for civil construction. […]"
Joint problem solving	"[…] they focused on construction companies, thus, for construction management companies their solution had to be redone. So, our partner adapted to the business model we had […]"
Joint problem solving	"[…] We have developed the system for about 1 year, together with this startup […]"
Joint problem solving	"[…] We had a deployment plan, and when we started to implement changes, needs for improvements started to get raised, errors. And there was dissatisfaction, the system does not work, how is it going to be? And then we needed to reinforce the concept of innovation […]"
Joint problem solving	"[…] on the interviews everyone was dissatisfied, hey it is very bad to report when I get home tired, to report 4 days later because sometimes I forget things that I have not written down, or a photo that I forgot to take. And then when the project is implemented in practice, using the cell phone, there were questions like: the cell phone is too small, I waste time here making notes that I used to do at home. […] […] We ran campaigns both internally and with the client to get around this issue. Thus, there were from stickers to stick on notebooks, to cups, email, intranet, workshops in the regional offices. […]"
Different organizational culture	"[…] First, there was the culture shock of working with the startup. […] […] in the beginning I could only upload one photo per item. But we had mapped out that we needed at least 10 photos per item to represent it well. […] […] When it came back for us to test it, we tested it on the cell phone, and you could upload 10 photos. When we went to check the report, strangely the report only showed one photo. […] […] their response was that we had only asked to upload 10 photos with the cell phone, not to take them to the report. […] […] Then I understood the rule. […]"
End-users' centrality	"[…] Customers participated so that we could understand exactly what the best way for them to receive information was, how it had to reach them, what was the best way for them to consume it. Thus, in the structuring of the business model we had active participation of our customers. […]"
End-users' centrality	"[…] Interviews with people from the field, precisely with the inspector who was going to do the monitoring, to understand what was interesting for him […] […] because without him nothing happens. […]"
End-users' centrality	"[…] If in the end of the day he does not fill the information up, nothing will be supplied. […]"
End-users centrality	"[…] The client's pain identification was done, and we created classifications in terms of pain levels, both for the client and for our operation as well, since the idea was to serve both sides. From there the indicators were derived, […]"
Long-term relationship	"[…] we involved from the vice president to the inspector who does the construction monitoring. As a reflex of this project, Iota ended up acquiring part of this startup. A long-term partnership was already being pursued […]"

Reported factors	Key stakeholders
Long-term relationship	"[…] nowadays we have a very solid relationship, in fact. With much greater transparency, and on the other hand, with a bit more tranquility regarding any deviations that might arise […]"
Information exchange	"[…] we used to have a monthly internal feedback meeting for our board and the presentation was precisely on these indicators. […] […] we had this follow up meetings to measure the achievement of our goals […]"
Communication	"[…] especially for people who work in this engineering department, it involves dealing with operational profiles and at the same time going to a meeting with management. Thus, you must change completely the way you deal with the environment, and report as well […]"
Communication	"[…] we even have training tomorrow on this, focused on behavioral skills to relate with stakeholders. […] […] a human resources consultancy was hired, precisely to give greater emphasis on this, how behavioral ability makes a difference, in the sense of communicating, understanding, empathizing with what the client is going through. […]"
Stakeholders identification and assessment	"[…] we have been working on a process remodeling, that involves several disciplines and one of them involves exactly the relationship with stakeholders, precisely regarding communication, proximity to the client, understanding their need and our need to adapt to each profile […]"
Stakeholders identification and assessment	"[…] (stakeholders assessment practices) Today there is no systematization like that. […] […] for stakeholders, we do not have anything systematized yet. […]"
Learning mindset	"[…] (the cultural shock) this was a big problem that we had to get around, but the outline was positive, with great learning associated. […]"
Learning mindset	"[…] Now I see that if in those day we were a bit more aware how innovation works, we would not have had that much suspicion. This was a great learning experience. […]"
Trust relationships	"[…] we started with high level of trust, but a level of trust based on an utopia, and we had this feeling that some magic would happen and in practice it is very different, it is very arduous. […]"
Trust relationships	"[…] In the beginning, sincerely we started with very high expectations […] […] our expectations were that it would be the same as hiring uber, google. […] […] with this innovation business model, there were a lot of suspicions. And we had serious conversations about transparency […] […] If it is not a sprint, which is a fortnight, and it is 4 weeks, please say that that you need 4 weeks and we will prepare for it, we will organize, and we will align expectations. […]"

Frame 23: Collaborative factors of the Digital Onsite Inspection Project

Source: elaborated by the author

Problems happened during implementation and were solved together by Engineering and Startup Teams. Referring to information exchange, status meetings were timely held during project execution. When discussing trust, Interviewee 6 reports they entered the project with a high level of trust, although problems and lack of transparency started distrust. These negative feelings were overcome through joint problem solving and serious talks about the importance of transparency to align expectations. Nowadays, Startup and Engineering Teams have a solid relationship, in which there is room for eventual friction that might come up.

Despite the cultural shock in the beginning of the partnerships with the startup, Interviewee 6 believes the outline was positive, with much learning associated. Two years after project conclusion, communication and relationship with stakeholders are discussed on the company as a tool to improve project results. However, no systematization exists on stakeholder identification and assessment. In this context, Frame 24 summarizes factors brough up on interview.

Highlighted factors	Digital Onsite Inspection
Definition of shared goals	+
Joint problem solving	+
Information exchange	+
Trust relationships	+
End-users' centrality	+
Learning mindset	+
Long-term relationship	+
Stakeholders identification and assessment	+
Communication	+
Different organizational culture	+

Frame 24: Summary of factors - Digital Onsite Inspection Project

Source: elaborated by the author

Seven out of eight relevant factors that connect collaboration and stakeholder management in manufacturing projects of industry 4.0 are also reported on the Digital Onsite Project, taken place on an EPCM consultancy. Although, top management support was not raised on the interview, perhaps because this support is implicit, considering organization has chosen to establish a specific department to handle process improvements and innovations.

Communication, different organizational culture, as well as stakeholders identification and assessment, were also reported for the Digital Onsite Project. They rest as leads for further investigation in the context of future research discussing collaboration and stakeholder management in industry 4.0 projects in EPCM companies.

4.1.1.5.3 CARNIVAL 4.0 PROJECT

The next project details a Carnival 4.0, in which a group of professors gathered with a samba school, universities and private companies to organize a Carnival 4.0 (Frame 25). It is described from the perspective of Interviewee 8. In this context, project goals were lapidated over time, through interactions with samba school and other stakeholders.

Since the beginning project stakeholders had to think about collaborative solutions. It started when considering how to fund the enterprise, and the solution was to have private companies contributing with physical resources and universities contributing with manpower.

Reported factors	Key stakeholders
Definition of shared goals	"[…] We wanted the theme to be Carnival 4.0 or Industry 4.0, but the Carnival Master asked us to tell them what this 4.0 revolution was. […] […] That was when they came up with the idea, […] […] the Carnival Master was brilliant at this point, as he proposed to do something about the future in which a little robot with artificial intelligence had an owner who grew up and left the little robot aside. The little robot starts reading books and learn about the first, the second revolution and begins to understand where he came from […]"
Definition of shared goals	"[…] The idea was lapidated over time. […]"
Definition of shared goals	"[…] we wondered how we could publicize it, since samba schools obviously could not pay this business. Thus, X, […] […] who has fantastic networking, he went to Universities in São Paulo, […] […] and asked if they wanted to make a carnival 4.0. Thus, Epsilon University together with Sigma, a university and a technology company were always paired. […]"
Joint problem solving	"[…] Sigma you are going to make your software available, not to the samba school, but to the university, and Epsilon's students designed the carnival floats, using virtual reality and augmented reality. Eta paired with Delta, if I am not mistaken, they made the monitoring system with bracelets for samba school's members. […]"
Joint problem solving	"[…] The company we work for is a medium-sized company, in which we cannot dispose of resources without revenues, so our idea was to bring in large companies. Thus, we started calling partners, our technology partners were diverse, […] […] we invited Sigma to participate in a marketing project, in which they did not partner with our company that is a profit oriented, but with universities, the workforce to use the software were students. […]"
Joint problem solving	"[…] We had to research a bracelet system that could transmit information in real time to a supervisory system. […]" "[…] We did harmony monitoring, as each participant had a bracelet, we could see them on a map, and we could see where an opening or closing was forming on the avenue. If it was too crowded with people or if a hole was opening. […]"
Information exchange	"[…] (information exchange) it was just about every day. […] […] We had a WhatsApp group with over two hundred people in it […]"
Trust relationships	"[…] we announced to companies they were entering a business with potential to reach up to 10 million people. Those who entered […] […] one of the (project) types is the time critical project. […] […] stakeholders that entered the project were aware of this characteristic […]"
End-users' centrality	"[…] Another action we had, that we were unable to implement, was a like a pokemon game. […] […] For example, if you were a tourist that came to see São Paulo's carnival and ate a mortadella sandwich from the municipal market, you would get a point […] […] And the idea was to get people in the VIP boxes as an incentive. […]"
Win-win solutions	"[…] And what could samba schools offer to universities? One day one of the universities could not go to the samba school because they were going to rehearse their university band. Then the samba school invited the university band to play with them at the court […]"

Reported factors	Key stakeholders
Informal social interactions	"[…] the first thing was to think who we knew that knew someone from a samba school. Thus, we searched for a link in our circle of friends, and we found someone who knew Omega. […]"
Stakeholders identification and assessment	"[…] Then we had to evaluate the Carnival Master to understand if he would accept something technological. For example, traditional schools would not accept our proposal, as they are more traditional. Thus, it had to be a Carnival Master that was open to our proposal. We started a conversation with the President of Omega and the Carnival Master. […]"

Frame 25: Collaborative factors of the Carnival 4.0 Project

Source: elaborated by the author

Win-win solutions were drawn as advertising was provided to private companies and practical experience to university students. In this context, informal social interactions were decisive to reach trustful partners. Stakeholders were identified and assessed to gather willingly partners. Specially the Carnival Master who had to be open for more technological themes.

Information exchange was a day-to-day routine, through a WhatsApp group with more than two hundred participants. As the project was time critical (Sauser et al., 2009), stakeholders were alerted features must be ready for the samba parade day when entering the project. However, some features were essential for the project, while others could be dispensed. In this context, Frame 26 summarizes factors brough up on interview.

Highlighted factors	Carnival 4.0
Definition of shared goals	+
Joint problem solving	+
Information exchange	+
Trust relationships	+
End-users' centrality	+
Stakeholders identification and assessment	+
Informal social interactions	+
Win-win solutions	+

Frame 26: Summary of factors - Carnival 4.0 Project

Source: elaborated by the author

The four factors questioned on interview protocol were also recognized on Carnival 4.0: definition of shared goals, joint problem solving, information exchange and trust relationships. Comparing to relevant factors emerging from the group of manufacturing projects, implementation of a mobile app to engage end-users was attempted and may be interpreted as end-users' centrality. Although, it unfortunately did not go through.

Besides, stakeholders identification and assessment, informal interactions and win-win solutions were also described. On the other hand, as a one-off event, it is expected learning mindset and long-term relationship would not influence on collaboration and stakeholder management in this project.

4.1.1.6 EMPIRICAL RESEARCH MODEL

Preliminary research model may be reevaluated to reach its final format. Initial factors connecting collaboration and stakeholder management were proposed based on literature: definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012), information exchange (Brunet & Forgues, 2019; Liu et al., 2019) and establishment of trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012). In-depth interviews confirmed their relevance on studied manufacturing projects. Therefore, they are maintained on empirical research model (Figure 12).

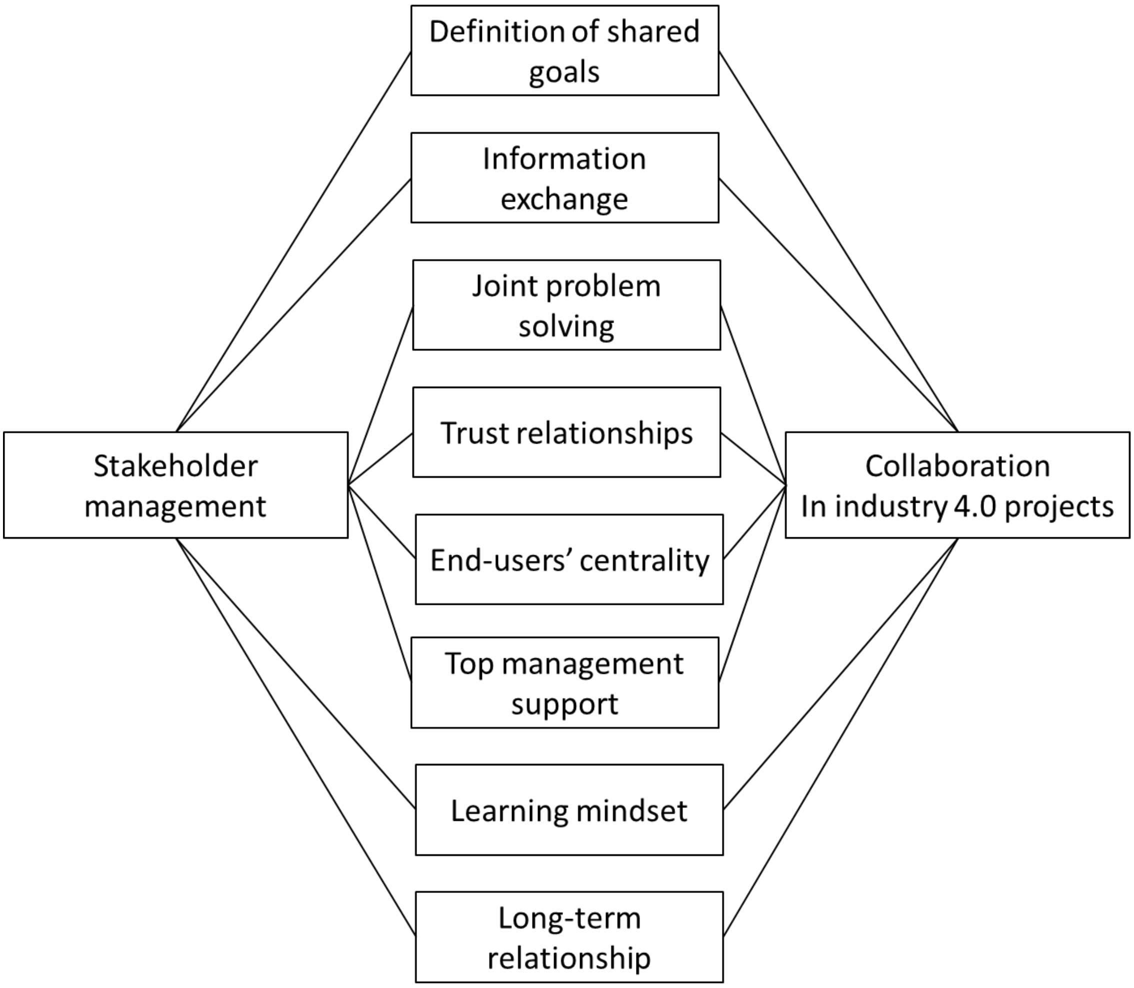

Figure 12: Empirical research model

Source: Elaborated by the author

Likewise, four other emergent factors were also found relevant, considered discussions of in-depth interviews while also mentioned in previous literature. As such end-users' centrality (Campatelli et al., 2016; Dewa et al., 2018; Hannola et al., 2018; Salehi, 2020; Serrador & Pinto, 2015; Sjödin, 2019), top management support (Agostini & Nosella, 2019; Mollaoglu et al., 2015; Rashid et al., 2018; Yadegaridehkordi et al., 2018), learning mindset (Couix & Hazard, 2013; Hannola et al., 2018; Herazo & Lizarralde, 2015; Nikitina & Lapiņa, 2019), and long-term relationships (Couix & Hazard, 2013; Senaratne & Sexton, 2004; Zuo et al., 2009), were included on empirical research model.

Questioning could be raised to the reasons defining which factors to include on the empirical research model. Given other factors were mentioned only in less than half of reported manufacturing projects, it is understood they should be further investigated. Sampling bias might also not be disregarded, as factors refer selection of interviewees and projects held by them. Besides, as discussed in the section 4.1.1.4, some factors like digital mindset and digital sponsor, for example, might only refer to projects taken place in companies with a certain maturity level of industry 4.0.

4.1.1.7 CENTRAL 4.0 TEAM

Four manufacturing projects reported their company have chosen to organize a specific team to handle experimentation and strategy definition for industry 4.0 projects, as shown in Frame 27. This kind of organization structure resembles a Project Management Office (PMO), which support project managers and project teams on strategy implementation (Bredillet et al., 2018; Dinsmore, 1999), as well as on exchange of good practices, as they constitute feedback loops in which partners explore new knowledge (R. Müller et al., 2013).

Manufacturing project	Central 4.0 Team
Smart Elevators	"[…] We have an area of digital transformation in the company and they direct us in many ways. We have our own task force, and we can do some local actions, but our digital transformation stakeholders are always present to ensure that they are feasible, both in the technical and strategic areas. […]" "[…] our partners, Gama and Kappa will always contact the Digital Transformation Team first. And the Digital Transformation Team will guide our strategy, as a company. […]" "[…] we have the status alignment meeting, […] […] to talk about the progress in each country and which are the guidelines the Digital Transformation Team is organizing centrally from Germany. […]"
Tablets for Maintenance	"[…] When Sigma started working with 4.0 a few years ago, a decision was made by the company's board to create a central department in Germany, and to start prospecting new technologies in the market that could be applied in the industry. A department with specialists was created to allow for a lot of experimentation. Also, each of the regions in which Sigma operates: South America, North America, Europe, and Asia has a central team of specialists working and developing 4.0 projects together with this central team from Germany. […]" "[…] The central 4.0 team that supports the implementation of these projects, based on the experiences from other plants, is also a stakeholder. […]"
Connected Production Supervisor Smart Outbound Logistics	"[…] We developed a solution internally, by a team called Rho Digital, based in France to develop internal solutions for Rho. We then deployed it here, for our supervisors. […]" "[…] We tropicalize some applications that sometimes do not make as much sense as they did in France […]"

Frame 27: Central 4.0 Team

Source: elaborated by the author

The Smart Elevator Project reports their company has organized a Central 4.0 Team which guides worldwide project implementation in collaboration with Regional Teams. In this context, close alignment between Central 4.0 and Regional Teams ensures strategical and technical aspects of the project are feasible. Besides, this type of structure facilitates joint problem solving and learning, because sometimes a problem has been experienced and dealt before. Also, this structure may centralize negotiations and formalization of agreements with interorganizational partners.

From the perspective of the Tablets for Maintenance Project, the Central 4.0 Team is also seen as a partner on implementation of industry 4.0 projects. They work as an information hub, as they assist factories with their implementation, register good practices and also lessons learnt to be used on following projects. Besides, Interviewee 4 reports the Company's Board has decided to create a Central 4.0 Team to start prospecting new technologies for industry 4.0 project, specifically to allow breath for experimentation.

Experimentation is experienced through pilot projects when end-users' contribution is gathered to improve final project configuration.

A Central 4.0 Team was also set up at the automotive manufacture that implemented two reported projects: Connected Production Supervisor and Smart Outbound Logistics Project. They figure as an industry 4.0 lighthouse (World Economic Forum & McKinsey & Company, 2019). The initial solution is provided by this Central Team and customized by Regional plants to suit specific characteristics. Pilot implementation is also reported as an opportunity to solve problems collaboratively and improve the final project result.

Hence, this research understands organizations interested on pursuing industry 4.0 developments could be favored by establishing a Central 4.0 Team. They would prospect new technology opportunities, negotiate with eventual interorganizational partners, and define strategic guidelines and indicators to be reached. Besides, considered empirical factors connecting collaboration and stakeholder management in industry 4.0 projects in manufacturing companies, Central 4.0 Team could work as a collaboration hub.

They would participate on definition of project goals and solve problems together with project teams, given their previous experience. They would ensure information is exchanged freely and build trust relationships with internal project teams, as well as eventual external partners. They could facilitate communication with top management for project support and promote end-users' involvement from early stages on industry 4.0 projects. Likewise, they would establish long-term relationships with project teams and evangelize on experimentation and learning mindset.

5 CONCLUSIONS

Aiming to propose a research model that explores the connection between collaboration and stakeholder management in industry 4.0 projects, eleven in-depth interviews were carried out with academic and professional experts. Prior, an SRL was developed to understand how capabilities and project management are portrait in 4IR literature. As a result, it demonstrated project management perspective in industry 4.0 projects was understudied. Besides, it showed industry 4.0 projects converge around collaboration among stakeholders.

Then, to improve knowledge about collaboration and project stakeholder management, another SRL has explored literature from a broader perspective. As a result, also considering results from the previous SRL, key factors connecting collaboration and stakeholder management in industry 4.0 projects were described on the preliminary research model, to prepare for empirical interventions.

Building on concepts studied on literature (Hasselblatt et al., 2018; Rashid et al., 2018; Schumacher et al., 2016; Schwab, 2017; Sjödin, 2019), this study's definition of industry 4.0 is established. Industry 4.0 comprises business integration implemented by disruptive technologies and achieved by transforming data into information and intelligence. It is supported by professionals, teams, and organizations that collaborate to put them together.

Discussing empirical conclusions from broader to stricter perspectives, different synonyms were usually employed to describe industry 4.0 projects on interviews. They were commonly described as digital projects, digitalization projects, or just 4.0 projects. Besides, it was clear industry 4.0 projects must target business improvements, such as servitized business models, customization of products to satisfy customers needs, faster decision making, improved efficiency, as well as intra and interorganizational integration. Nevertheless, exponential technologies support industry 4.0 projects.

In the context of technologies, it is argued not only ten technologies support industry 4.0 projects, as argued before. As other technologies were reported as conducive of industry 4.0, like AGVs, drones, and RFID. Industry 4.0 technologies such as big data analytics, simulation of interconnected machines, IoT, cyber-physical systems, cloud computing, virtual or augmented reality, cyber security, collaborative robots, additive manufacturing or 3D printing, artificial intelligence, AGV, drones and RFID must be seen as tools on a shelf to be applied according to the business need and maturity of the project at hand. Valid to note that as new technologies keep coming up, the content of this shelf is likely to be increased more and more in the near future.

Discussing maturity of industry 4.0 projects, Moeuf et al. (2018), supported by Porter and Heppelmannn (2014), establish smart products and manufacturing projects may be evaluated in terms of their capacity to: monitor, control, optimize and provide autonomy, progressively listed from low to high maturity projects (Porter & Heppelmann, 2014). In this context, almost half of empirical projects reported on interviews were monitoring projects. They range from smart glasses used by production workers to enable documents consultation and virtual assistance by experts, to projects in which monitoring is an initial phase towards more complex control and optimization applications.

Also, a third of reported projects enable control. On manufacturing sector, they span from tablets used for preventive maintenance in a resin manufacture, to supply chain integration of logistics operators in an automotive manufacture. From the education sector, one of the interviewees reported implementation of a physical and digital laboratory by a University. It provides simulation software, among other tools, to promote execution of collaborative research projects by professors, students, and the business sectors.

At last, three reported industry 4.0 projects delivered optimization. On manufacturing sector, two of them implement servitization business models, in which manufactures offer associated digital services together with their products. On insurance sector, the third optimization project provides discounts on insurance policies which are customized based on users' behavior.

Considering there were no reported projects targeting manufacturing autonomy, and many of them still focus on monitoring applications, results suggest industry 4.0 projects are still on its initial stages. Nevertheless, reported manufacturing projects aimed at optimization offer customers innovative, service-centered, and digital products. Hence, it could indicate opportunities to deepen industry 4.0 developments might lie on collaborative new business models connecting end-users and manufactures, which has been previously highlighted on literature (Agostini & Nosella, 2019; Garcia-Muiña et al., 2019; Lerch & Gotsch, 2015; Parida & Wincent, 2019; Qu et al., 2019).

From a different perspective, optimization projects show information being produced based on data and offered as a service for manufacturing costumers. Besides, interviews highlight industry 4.0 projects are deeply connected with data management. Thus, generation of data, and consequent information and intelligence could differentiate automation and industry 4.0 projects.

Past broader perspectives of industry 4.0 projects, this research presents its final empirical research model with eight key factors that connect collaboration and stakeholder management practices in manufacturing projects of industry 4.0. As such, it started with four factors as base for explorative interview protocol: definition of shared goals (Aarseth et al., 2012; Faraj & Sambamurthy, 2006), joint problem solving (Nidumolu et al., 2014; Santos et al., 2012), information exchange (Brunet & Forgues, 2019; Liu et al., 2019), establishment of trust relationships (Bond-Barnard et al., 2013; Thamhain, 2012).

Considering the sample of industry 4.0 projects reported in manufactures, this research understands those four factors are relevant to connect collaboration and stakeholder management. To complement its main research findings, other four factors, not directly discussed on interview protocol, emerged during empirical interventions. As such, top management support, end-users' centrality, learning mindset and long-term relationship are also considered relevant factors connecting collaboration and stakeholder management in manufacturing projects of industry 4.0 and comprise the empirical research model.

Relevance of each of these factors are supported by previous literature. Definition of shared goals is identified as a "common-glue" (Fellows & Liu, 2012) of collaborative project management (Faraj & Sambamurthy, 2006; Fellows & Liu, 2012; Gray, 1989; Ika & Donnelly, 2017; Kernel, 2005; Lin et al., 2018; Nidumolu et al., 2014). When stakeholder management assures stakeholders define project goals together, they align expectations, which improves their commitment to project results and associated risks.

On the other hand, joint problem solving enable different interpretations to challenge and refine ideas (Campatelli et al., 2016; Ratzmann et al., 2018; Salehi, 2020; Sjödin, 2019). Thus, when project stakeholders are open to find solutions collaboratively, they consider different perspectives to interactively put together innovative solutions. In collaborative projects, it is also relevant stakeholder management ensures information is exchanged openly and timely to communicate project decisions and improve stakeholder engagement. Authors state frequent connections across hierarchical levels facilitate direct communication (Herazo & Lizarralde, 2015).

Trust relationships improve joint problem solving (Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Sjödin, 2019), and reduce friction among professionals (Sjödin, 2019). Thus, project management should be attentive for stakeholders needs and interests to strengthen trust relationships and build win-win solutions. Turning to top management support, authors highlight managers must be committed to change process (Agostini & Nosella, 2019; Mollaoglu et al., 2015; Rashid et al., 2018; Yadegaridehkordi et al., 2018). As such, top management support eases industry 4.0 projects implementation, given they are committed to experimentation.

Referring to end-users' centrality, studies point out end-users must be involved early in projects (Campatelli et al., 2016; Dewa et al., 2018; Hannola et al., 2018; Salehi, 2020; Serrador & Pinto, 2015; Sjödin, 2019). Hence, this study argues end-users should be involved early with industry 4.0 projects, to participate on definition of project goals and to solve problems together. Their tacit knowledge and experience may improve project results, be them internal or external end-users. However, empirical interviews showed this mindset might not be entirely absorbed by researched organizations.

Interviews have also shown studied manufactures regard industry 4.0 projects with a learning mindset, open for trial and error, and preparing for further endeavors. Nikitina and Lapina (2019), for example, pinpoint industry 4.0 professionals must be committed to continuous learning (Nikitina & Lapiņa, 2019), while Couix and Hazard (2013) argues collective learning facilitates collaboration among project stakeholders. As such, manufactures interested on industry 4.0 developments should cultivate learning mindset on their professionals, promoting experimentation and valuing associated learning during setbacks.

Finally, long-term relationships are not discussed on literature about capabilities and project management in industry 4.0. However, they are seen to deepen relationships, in the context of collaboration and stakeholder management (Couix & Hazard, 2013). Project stakeholders learn to work together, which might indicate Project Management Offices (PMO) or Central 4.0 Teams could facilitate industry 4.0 relationships and evolution process.

Lastly, empirical interventions ratified findings from the SRL (Section 3.1), given interviews reflected all six perspectives of project capabilities described. Strategic capabilities of industry 4.0 projects as new business models are characterized by the Smart Elevators Project. Supported by a network of companies working closely, a servitized business model delivers a product-service to manufacturing clients. Likewise, innovation capabilities of industry 4.0 projects, are reported on the Tablets for Maintenance Project and Connected Production Supervisor Project, in which joint problem solving and experimentation enabled collaboration and project implementation.

Human capabilities are characterized by technical and soft skills of project professionals. They are exemplified on the Central ERP Project, for example, in which professionals had to overcome technical difficulties and work together to connect different configuration equipment to a central monitoring system. Technological capabilities span all reported projects. The NPS Feedback Project, for example, exemplify the use of artificial intelligence to automatically analyze feedbacks from manufacturing customers and retrofit them to improve products and processes.

Data analysis capabilities is a backbone of industry 4.0 projects. The Smart Field Manager Project reports satellite pictures being analyzed by artificial intelligence to return customized recommendations to agricultural clients of a chemical manufacture. Last but not least, project management capabilities are characterized when the Tablets for Maintenance Project or the Connected Production Supervisor Project describe how they defined shared project goals aligned with company strategy and how project stakeholders were evaluated to establish adequate engagement actions.

6 CONTRIBUTIONS FOR THEORY AND PRACTICE

As its main contribution for theory, this exploratory study proposes an empirical research model showing key factors connecting collaboration and stakeholder management in manufacturing projects of industry 4.0. As such, collaborative industry 4.0 projects rely on definition of shared goals, joint problem solving, information exchange, trust relationships, top management support, end-users' centrality, learning mindset and long-term relationships. In this context, stakeholder management is the tool to manage these key factors.

Hence, these findings add to the body of knowledge of capabilities and project management in industry 4.0, as it fills a recognized research gap. Besides, it also characterizes different industry 4.0 projects, their associated technologies, their key stakeholders, their data dependency, as well as monitoring, control optimization or autonomy capacities.

Considering the reported projects rendering optimization to manufactures, it was verified they implemented customer centered and digitalized business models. This could indicate industry 4.0 developments are deepened by innovative business models. This finding corroborates previous studies by industry 4.0 authors (Agostini & Nosella, 2019; Garcia-Muiña et al., 2019; Lerch & Gotsch, 2015; Parida & Wincent, 2019; Qu et al., 2019) and indicates new avenues for further research.

Turning to its contribution to practice, this research identified manufacturing companies have chosen to organize a Central 4.0 Team to manage strategy definition and experimentation for industry 4.0 projects. They specialize on prospecting new technologies, negotiating with interorganizational partners, as well as defining strategic guidelines to be implemented and indicators to be reached. Besides, Central 4.0 Team act as a collaboration hub, as they exchange experiences and lessons learnt, given empirical factors connecting collaboration and stakeholder management in industry 4.0 projects in manufactures.

As industry 4.0 is still a new phenomenon about which many practitioners are curious and need information. This research attempts to bring academic knowledge to practitioners by characterizing different real-life industry 4.0 projects. Besides, it attempts to distinguish automations and industry 4.0 projects. Moreover, it presents the commonly referred list of technologies comprising industry 4.0 projects, despite ascertaining they shall be seen as a set of available tools on a shelf to address specific business needs.

7 LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

As any empirical research, limitations accompany this study. They started during revision of literature, permeated data collection and data analysis procedures. During review of previous literature, the choice of keywords to characterize industry 4.0 projects may have limited the studies under investigation. Despite efforts taken to ensure adequate synonyms were selected, perhaps other synonyms would be aggregated once empirical data is known.

Referring to data collection, after interview transcripts were read and cross compared, other questions were identified as relevant to clarify specific issues or enable further comparison among interviews. Hence, if a new round of interviews would had been possible, findings would have been even stronger. Another limitation of data collection procedure lies on in-depth interviews themselves, as they do not provide observation opportunities and grasping different perspective other than the interviewees'.

During data analysis, considering the data we had in hand, other analysis was possible. However, time constraints have postponed them to prioritize research main focus. They range from information to characterize benefits of manufacturing projects of industry 4.0, reported problems and difficulties, issues distinguishing automation and 4.0 projects, through to reported agile project management and project portfolio management practices. Besides, they characterize industry 4.0 as an evolutionary process with continuous improvements and new ideas.

Focusing on further qualitative research opportunities, industry 4.0 project projects implementing servitization business model were identified with potential to deliver business optimization. Thus, future research should concentrate on deepening knowledge about servitization projects, for example, to understand which are their main barriers and what are the antecedents for successful implementation. Besides, to understand how end-users' and eventual interorganizational partners are involved with project decisions.

Another interesting opportunity for future research lies on a longitudinal study accompanying industry 4.0 developments in one of the interviewed manufactures. This would deepen understanding about how an industry 4.0 program evolve over a period of time, as well as understanding on how stakeholder relationships are managed throughout lifecycle. On the other hand, targeting a quantitative approach, future research could attempt to build a quantitative scale to test identified factors connecting collaboration and stakeholder management.

Future research could also broaden investigation about the relationship between collaboration and stakeholder management in industry 4.0 projects taken place in Universities, as well as in EPCMs. Moreover, other factors mentioned by specific empirical projects could be further investigated by qualitative research on collaboration and stakeholder management in industry 4.0 projects in manufactures.

As such digital mindset, digital sponsor, stakeholders identification and assessment, training, win-win solutions, different organizational cultures, informal social interactions, leadership coordination, and effective project sponsoring could be leads for further research. For example, factors like digital mindset and digital sponsor might refer to projects taken place in companies with a certain maturity level of industry 4.0, as discussed in section 4.1.1.4.

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ANNEX I – LETTER TO INVITE EXPERTS FOR INTERVIEWS

São Paulo, 24 de maio de 2020

Prezado Prof. Dr.,

Assunto: Pesquisa acadêmica sobre a relação entre gerenciamento de stakeholders de projetos e colaboração no âmbito da indústria 4.0

Sou aluna do mestrado em gerenciamento de projetos da Universidade Nove de Julho (UNINOVE), orientada pelo Prof. Dr. Roque Rabechini Jr. Como parte da minha dissertação, temos estudado a indústria 4.0, sob a ótica do gerenciamento de projetos. E identificamos uma oportunidade de pesquisa empírica relacionada à colaboração entre os *stakeholders* dos projetos 4.0. Após revisar a literatura acerca dos temas acima, desenvolvemos um modelo de pesquisa empírico inicial.

Tendo em vista o trabalho desenvolvido pelo Sr., relacionado com o referido tema de pesquisa, gostaríamos de entrevistá-lo como parte da primeira etapa empírica da dissertação. Seria uma conversa de cerca de 1 hora, pelo aplicativo zoom, tendo como intuito complementar o trabalho de pesquisa inicial.

Caso seja possível, gostaríamos de entender quais os melhores dias e horários para esta conversa.

Agradecemos antecipadamente.

Atenciosamente,

Danielle Cruz Paiva

ANNEXII – PROTOCOL FOR DATA COLLECTION AND INTERVIEWS

INSTRUÇÕES PARA O ENTREVISTADOR

A – Declaração de abertura

Considerando as mudanças tecnológicas e de negócios no contexto da indústria 4.0, que permitem a integração horizontal e vertical das organizações, além da implantação de modelos de negócios colaborativos. Ainda, levando em consideração que diferentes stakeholders, entes que são influenciados ou que podem influenciar o projeto, interagem. Esta pesquisa busca analisar a relação entre a gestão de stakeholders de projetos e a colaboração na indústria 4.0. Por motivos de ética e segurança, todos os dados obtidos serão mantidos sob absoluto sigilo profissional e pessoal, no entanto, é necessário que os resultados desta pesquisa sejam divulgados.

B - Dados do Pesquisador e Orientador

Pesquisador: Danielle Cruz Paiva

Professor Orientador: Prof. Dr. Roque Rabechini Jr.

C - Condições da entrevista

Quem será entrevistado?

Nome: ____

Data da entrevista: ____

Local: ____

Duração da entrevista: ____´

Área de pesquisa: ____

Período no qual acontecerão as entrevistas?

R: As entrevistas acontecerão nos meses de julho e agosto de 2020.

Local?

R: por vídeo conferência

Quanto tempo?

R: Até 60 min.

Como será conduzida a entrevista?

R: Eletrônico por meio de vídeo conferência.

D – Conceitos a serem investigados

A literatura especializada caracteriza a indústria 4.0 como uma onda de transformações, na qual tecnologias digitais integram cadeias produtivas e empresas fabris em modelos de negócios colaborativos centrados em serviços.

1. Neste contexto, brevemente, como o Sr. caracterizaria um projeto da indústria 4.0?
2. Como você explica a diferença entre projetos de automação e projetos da indústria 4.0?
3. Poderia caracterizar um clássico projeto da indústria 4.0 do qual participou? / sobre o qual estudou?

Constructo	**Definição**	**Artigos**
Caracterização de projetos da indústria 4.0	Integração vertical e horizontal de manufaturas, promovida por tecnologias disruptivas e colaboração entre profissionais, equipes e organizações.	(Agostini & Nosella, 2019; Ferreira et al., 2017; Hasselblatt et al., 2018; Lerch & Gotsch, 2015; Moeuf et al., 2019; Parida & Wincent, 2019; Ratzmann et al., 2018; Schumacher et al., 2016; Walker & Lloyd-Walker, 2019)

Considerando que diferentes stakeholders são influenciados ou podem influenciar o projeto, e que eles têm diferentes graus de poder.

4. Você poderia caracterizar os diferentes stakeholders neste projeto da indústria 4.0, considerando sua influência e poder?
5. Quais práticas de gerenciamento de partes interessadas foram empregadas neste projeto da indústria 4.0 do qual você participou?
6. Como você engajou as partes interessadas no projeto?

Constructo	**Definição**	**Artigos**
Caracterização dos stakeholders	Stakeholders são pessoas ou organizações que influenciam ou são influenciados pelos projetos. Podendo ser classificados quanto ao poder e influência que exercem.	(Aaltonen & Kujala, 2016; Bourne & Walker, 2008; Eskerod et al., 2015; Olander & Landin, 2005; PMI, 2017)
Práticas de gerenciamento de stakeholders	Stakeholders são identificados e classificados, para que seu engajamento seja gerenciado e monitorado ao longo do ciclo de vida do projeto.	(Aaltonen & Kujala, 2016; Bourne & Walker, 2008; Eskerod et al., 2015; Olander & Landin, 2005; PMI, 2017)

7. Como foram estabelecidas as metas do projeto?
8. Como os *stakeholders* participaram?
9. Como as informações foram trocadas entre os *stakeholders* do projeto?
10. Como eventuais problemas ou situações não planejadas foram tratados?
11. Como as partes interessadas participaram?
12. Quanto os *stakeholders* do projeto confiam uns nos outros?
13. Quais atividades e práticas facilitaram a colaboração no projeto?

Constructo	Definição	Artigos
Definição de objetivos compartilhada	Clara definição de objetivos, alinhada com a estratégia organizacional.	(Aranda-Mena et al., 2009; Caruso, 2018; Faraj & Sambamurthy, 2006; Fellows & Liu, 2012; Gray, 1989; Ika & Donnelly, 2017; Kernel, 2005; Nidumolu et al., 2014; Ratzmann et al., 2018; Suprapto et al., 2015; Walker & Rowlinson, 2019)
Troca de informações	Interação e comunicação levando ao compartilhamento aberto de informações entre os stakeholders.	(Bond-Barnard et al., 2013; Campatelli et al., 2016; El-Gohary & El-Diraby, 2010; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Rashid et al., 2018; Ratzmann et al., 2018; Singh et al., 2019; Sjödin, 2019; Soh et al., 2011; Walker & Lloyd-Walker, 2019; Xue et al., 2018)
Solução conjunta de problemas	Trabalhar junto, avaliando riscos e experimentando. Levando em consideração conhecimentos complementares, experiências e perspectivas diferentes.	(Aarseth et al., 2012; González et al., 2015; Gray, 1989; Ika & Donnelly, 2017; Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Ratzmann et al., 2018; Rijke et al., 2014; Santos et al., 2012; Senaratne & Sexton, 2004; Sjödin, 2019; Suprapto et al., 2015)
Estabelecimento de relação de confiança	Estabelecimento de relações baseadas em interações, levando à confiança entre os stakeholders.	(Moeuf et al., 2019; Nikitina & Lapiņa, 2019; Parida & Wincent, 2019; Ratzmann et al., 2018; Roßmann et al., 2018; Walker & Lloyd-Walker, 2019; Xue et al., 2018)
Colaboração	Colaboração ocorre quando stakeholders autônomos utilizam regras comuns para atuar e decidir sobre um problema que os afeta.	(Baiden & Price, 2011; Bedwell et al., 2012; Suprapto et al., 2015; Wood & Gray, 1991)