Societal Dimensions of Digital Transformation:
Implications of Digital Technologies on Stakeholder Groups in the Context of Ecosystem

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Societal Dimensions of Digital Transformation:

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With the expansion of underpinning technologies, advanced digital technologies and innovations are transforming many aspects of human daily life, such as education, health, and business productivity. Today, the implementation of digital technologies is considered a characteristic of modern societies. However, while society is becoming increasingly dependent on digital technology and e-innovations in business and trade, the need for paying adequate attention to the societal side of this transformation is also becoming prominent. As a generation setting the future orientation of emerging digital innovations, we hold the ethical responsibility to build an inclusive playground for the current and future generations. Such an ethical responsibility urges attending to societal and humanitarian concerns of the current digital transformation into account. As our perception has evolved over the past decades, we perceive societal consideration as a backbone supporting long-term value creation and equitable welfare. Hence, this PhD thesis investigates the associated societal impact of digital technologies.

Keywords: Digitisation, Digitalisation, Digital Transformation, Stakeholder, Inclusion, Ecosystem, Agriculture.

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Kind note to the reader:
Dear reader, the authors used zero papers to develop this thesis. It means all the readings, note-taking, text synthesising, table preparations, commentation, documentations, and storage were conducted using digital devices and technologies. To keep this study green, please only print whenever necessary.

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1. Introduction

This thesis is comprised of four studies, designed in the format of scholarly articles and focused on the impact of digital technologies on stakeholders in the context of the ecosystem. Each article represents a chapter of the thesis. The articles covered three levels of analysis, including the analysis of the relationship between digital technologies and individual-level stakeholders, the analysis of the relationship between digital technologies on enterprise communication, and finally, the analysis of the relationship between digital technologies and ecosystem-level stakeholders. The first and second articles studied different perspectives, whereas the third and fourth articles are interrelated. Across all four studies, digital transformation discussion remained a constant theme, while the impact on stakeholders is contextualised based on different aspects studied in each article. Chapters one and four are published in peer-reviewed journals, and chapters two and three have been accepted for presentation at conferences and are in the process of submission to peer-reviewed journals.

The discussion in this introductory chapter is designed as follows. First, the chapter reviews the digital transformation literature and its impact on value delivered to society. The literature suggests the impact of digital technologies on societal value is positive (Matt et al., 2015; Linkov et al., 2018; Jovanović et al., 2018). However, digital technologies are developed and implemented in a complex context of influence exchange between the enterprise and society. Thus, the chapter covers the argument that since digital technologies have a societal impact, they cannot be discussed as discrete technologies but instead need to be studied in the ecosystem context (Matt et al., 2015; Woerner & Wixom, 2015; Majchrzak et al., 2016; Nambisan, 2017; L. Li et al., 2018). Moreover, the concept of ecosystem implies dynamic interaction between stakeholders. Therefore, the chapter covers the argument that taking an ecosystem approach to digital technologies needs to consider the impact of digital technologies on diverse stakeholder groups. The literature emphasises stakeholders' value and posits that societal value needs to be discussed concerning the value perceived by stakeholders (Donaldson & Preston, 1995; Khoury et al., 1999; Jackson & Hawker, 2001; Lea, 2002; Van Marrewijk, 2003; Hopkins, 2003). The introduction includes an overarching research question that this thesis aims to address.

1.1. Digital transformation and societal value

Digital technologies are transforming every aspect of society. Digitally enabled innovations in e-commerce, e-learning, and digitalisation of different processes at the institutional level, such as e-government, have evolved to make digital technologies a new reality of the time. Today, developments in digital technologies in mobile applications, cloud computing, social media, augmented reality, and data analytics are transforming our understanding of the concept of innovation at accelerated rates (Nambisan, 2017). For instance, smartphones reached a 40% global diffusion rate within ten years, while it took electricity almost 40 years to reach a 10% diffusion rate (Sussan & Acs, 2017). In addition to the fast expansion of digital technologies, scholars argue that the digital transformation in knowledge-intensive industries can lead to significant economic growth (Fritsch & Mueller, 2008). Such a massive transformation is believed to bring welfare and abundance to society (Brynjolfsson & McAfee, 2013). Furthermore, with the continued emergence of advanced information technologies, like Artificial Intelligence (AI), societies can expect even greater e-enabled innovations in aspects that were traditionally outside this domain, like health (Fuchs, 2008) and agriculture (Jha et al., 2016). Hence, digital technologies are regarded as the backbone of the transformation towards achieving societal value (Fromhold-Eisebith, 2017).

However, while societies are becoming increasingly dependent on digital technologies and e-innovations, scholars warn that limited attention is paid to societal concerns about applying digital technologies in enterprise value delivery (Dewan et al., 2014). Scholars assert that consequences and concerns of digital technologies tend to move beyond the enterprise boundaries to include social and environmental issues (Dentchev et al., 2016). Such a societal impact can be simultaneously perceived as constructive or disadvantageous by different groups (Brynjolfsson & Saunders, 2009). The academic literature has documented detrimental impacts of digital technologies, e.g. reinforcing social inequalities (Riaz, 2015), but also it shows that applying the same technologies can lead to improvement in some areas of society. For instance, e-learning platforms give access to certain social groups that otherwise would have been left with limited access to education (Azeiteiro et al., 2015). Hence, addressing societal concerns about emerging digital technologies and balancing their impact on society is necessary for achieving long-term economic value creation (Täuscher & Abdelkafi, 2018). Therefore, the long-term sustainability of digital technologies requires developing an inclusive and dynamic understanding of the role of digital technologies and their respective impact on different groups (Sussan & Acs, 2017). Such an approach has necessitated investigating the impact of digital technologies in multiple interconnected ecosystems (Majchrzak et al., 2016).

1.2. Digital transformation in the context of ecosystem

As discussed in chapter 2, advanced digital technologies have dissolved the boundaries of the enterprise (Matt et al., 2015; Woerner & Wixom, 2015; Nambisan, 2017; L. Li et al., 2018). Hence, digital technologies cannot be studied isolated from their respective external environment and stakeholders (Majchrzak et al., 2016). The term ecosystem is metaphorically applied to refer to the dynamic interaction between socioeconomic stakeholders. Digital transformation in such a context can also lead to transformation in the perception of value: while the ultimate purpose of a business ecosystem is maximising value for the collaborating network, a digitally empowered ecosystem can optimise the performance of all stakeholders with implications for the entire economy (Stam, 2015; Acs et al., 2017). In such an ecosystem, economic stakeholders, such as the enterprise, are motivated by enhanced efficiency and competitiveness, empowered by digital technologies, to deliver private value (Matt et al., 2015; Stock & Seliger, 2016; El Hilali & El Manouar, 2018; Jovanović et al., 2018). Yet, private value delivery in the digital transformation context can scale up to involve the interest of broader stakeholder groups (Dini et al., 2011; Hess et al., 2016; Sussan & Acs, 2017; L. Li et al., 2018). As a result, digital technologies in the ecosystem context create an environment where different stakeholders can innovate and engage in societal value development (W. Li et al., 2012). Therefore, in a dynamic ecosystem of interactions, value creation and social concepts like stakeholder engagement are transformed towards gaining more societal orientation that can impact diversified stakeholder groups. Hence, understanding the impact of digital technologies in the context of the ecosystem has necessitated investigating the impact of digital technologies on the stakeholders who are subject to such a transformation.

1.3. Digital transformation and impact on stakeholders

Stakeholders are groups or individuals that can influence or be influenced by the enterprise's performance (Freeman, 2010). In the contemporary business environment, stakeholders expect the value delivery of digital transformation to go beyond pure economic value (Pappas et al., 2018). In addition to economic value, stakeholders' expectations include a spectrum of value delivery that, for example, includes addressing social and environmental concerns, maintaining a sustainable infrastructure and supply chain, and enabling interaction with stakeholders (Boons & Lüdeke-

Freund, 2013). Equally, digital technologies seem to accommodate these demands (Täuscher & Abdelkafi, 2018). Scholars argue that in addition to economic value, digital technologies can positively influence understanding the expectations of external stakeholders (Jovanović et al., 2018). For example, scholars such as Pappas et al. (2018) assert that emerging digital technologies, in addition to accuracy and efficiency, can also fulfil stakeholders' societal expectations. Therefore, developing an insight into value delivery enabled by digital transformation in the ecosystem requires understanding the impact of digital technologies on the value expectations of stakeholders.

1.4. Research Question

Reviewing the literature shows that digital technologies conceptually can contribute to transforming societies and delivering societal well-being (Linkov et al., 2018). Also, the literature suggests that digital technologies can be applied in designing value delivery models that allow the enterprise to 'do good and 'do well' (Täuscher & Abdelkafi, 2018). A reciprocal relation with the external environment implies the impact of digital technologies is not limited to delivering economic value, but it can have an impact on fulfilling the expectation of the stakeholders (Jovanović et al., 2018). Additionally, recent studies confirm that human well-being is better satisfied in societies with higher levels of digital technology adoption (Ibid). However, reviewing the literature also reveals certain gaps in developing insight into the impact of digital technologies on stakeholders that require further investigation. First, the literature suggests that digitisation and digitalisation have different implications for societal value delivery (Matt et al., 2015; Legner et al., 2017; Gray et al., 2013; Stock & Seliger, 2016). However, most of the current studies take the concept of digital transformation as a whole when studying the impact of digital technologies on society. Chapters two and three explain that digital technologies are developed on different technological foundations with different societal implications. Hence, paying adequate attention to the underpinning technical structure of digital technologies is necessary for developing insight into the impact. Second, the tendency in the literature to conclude the impact of digital transformation is generally positive for the entire ecosystem seems to be influenced by macro level perspective (Fritsch & Mueller, 2008; Brynjolfsson & McAfee, 2013; Jha et al., 2016; Fromhold-Eisebith, 2017; Linkov et al., 2018; Täuscher & Abdelkafi, 2018; Jovanović et al., 2018). The same macro-level perspective is observed when outlining the possible drawbacks in areas such as digital agriculture (Wolfert et al., 2017; Regan, 2019). Conceptually, the impact of digital technologies on the macro-level of the ecosystem can be expected to be different from the micro-level. Chapter one demonstrated that the positive impact at the macro level cannot always be interpreted as a positive impact at the micro-level on individuals. Thus, the transition of impact based on the level of the ecosystem on stakeholder groups needs to be traced. This aspect is not clearly outlined in the literature. Third, the literature posits the impact of digital technologies needs to be discussed in terms of the stakeholders' value expectations (Matt et al., 2015; Legner et al., 2017; Gray et al., 2013; Stock & Seliger, 2016). However, as reviewed in chapters three and four, stakeholders are not homogeneous groups and have different influences when interacting in the ecosystem. Stakeholders can also take different structures such as individual stakeholders, enterprise stakeholders, and societal stakeholders with a mix of economic and non-economic value expectations. The structural differences between stakeholders suggest that value within each group can be perceived differently and communicated differently in the ecosystem. The literature does not clearly outline the impact of digital technologies with respect to the stakeholder structures and their leveraged level of influence in the ecosystem. Stakeholders' structures need to be further identified and mapped based on the level of impact. Hence, to develop an insight into the impact of digital technologies on stakeholders in the ecosystem context, this thesis asks the following question:

What are the implications of the two levels of digital transformation (digitisation and digitalisation) on the expectation of stakeholders' value with respect to individual stakeholders, enterprise communication of stakeholder value, and conceptual stakeholder inclusion in the ecosystem context?

This research question can be addressed from different perspectives. Each chapter of this thesis studies a dimension of the impact of digital technologies on stakeholders and focuses on a specific gap in the literature, as explained in the next section. The articles cover three levels of analysis: the analysis of the relationship between digital technologies and individual-level stakeholders, covered in the first article, the analysis of the relationship between digital technologies and enterprise-level communication, covered in the second article, and the analysis of the relationship between digital technologies and ecosystem-level stakeholders covered in the third and fourth studies.

1.5. Gap analysis: Digital transformation and stakeholder value expectation in the context of the ecosystem

The literature shows that the role of digital technologies in transforming societies and delivering societal value and fulfilling the expectation of the stakeholders is conceptually acknowledged (Jovanović et al., 2018; Linkov et al., 2018; Täuscher & Abdelkafi, 2018). However, this thesis has identified certain gaps in the literature that require further investigation. Addressing these gaps can enhance our understanding of the impact of digital technologies on stakeholders.

- **Digital technologies and individual stakeholders (women) in managerial roles in venture capital-funded digital start-ups**

  This article focuses on investigating the impact of recent digital transformation on women as individual stakeholders in the context of the entrepreneurial ecosystem. The current literature, for example, Krieger-Boden and Sorgner (2018), argue that digital entrepreneurship does not have a levelling effect on women in the entrepreneurial ecosystem. Also, previous findings had suggested the negative impact of women's composition in leadership on attracting venture capital funds (Robb & Coleman, 2010). Currently, due to increased social awareness among many stakeholders involved in entrepreneurship, there is much renewed interest in the gender dimension. This argument is supported by evidence of improved funding practice in fields where digital technologies were applied (Mallia & Windels, 2011; Johnson et al., 2018; Gafni et al., 2021). However, there is no updated analysis on whether the recent social and technological trends and demands have changed the practice of venture funding in the entrepreneurial ecosystem. Additionally, most of the previous studies were mainly concerned with women's participation in general in the contexts like the barriers to entrepreneurship. However, a more specific aspect of the impact of digital transformation on women, like integration into managerial roles, is essential to investigate the impact of the recent digital technology development. Also, fast-evolving digitalisation-led innovations like Artificial Intelligence, Big Data analytics and Blockchain technologies in digital start-ups necessitate assessing the impact of this digital transformation in the entrepreneurial ecosystem on micro-level stakeholders, such as the impact on improving systemic inequalities concerning gender. Hence, updated analysis and results are needed to provide insight into the impact of the evolving levels of digital technologies on women, especially in newly established digital start-ups.

- **Digital technologies and enterprise-level communication of societal value in the ecosystem:**

  This article focuses on enterprise and organisational level stakeholders and investigates the impact of communication of digital technologies on communication of social value in the Canadian Agri-food ecosystem. The literature posits that advanced digital technologies have dissolved the boundaries of the enterprise (Matt et al., 2015; Woerner & Wixom, 2015; Nambisan, 2017; L. Li et al., 2018). Consequently, it changes the perception of the enterprise as the sole source of value (Gray et al., 2013; Stock & Seliger, 2016; Legner et al., 2017; W. Li et al., 2012; Pinzone et al., 2018; Manda & Ben Dhaou, 2019). The shift in the perception of the source of value is attributed to innovations in digitalisation that facilitate setting strategies for interacting with external stakeholders and enhancing societal value delivery. In contrast, digitisation strategies are criticised for being focused on internal efficiencies that make them misaligned with the external environment (Legner et al., 2017). Although the impact of digital technologies on value delivery to stakeholders is conceptually outlined, there is no evidence whether communication of digitalisation technologies, which are expected to deliver societal value, has an impact on driving the communication of value appreciated by stakeholders. Therefore, examining the relationship between the communication of two levels of digital transformation and social communication at the enterprise level is essential to understanding the impact of digital technologies on stakeholder value in the ecosystem.

- **Emerging digitally-enabled concepts and conceptualising stakeholder inclusion in the ecosystem**

  This article focuses on investigating the conceptual impact of emerging technological concepts on stakeholder inclusion in agriculture ecosystems. The literature posits that digital technologies and innovations are transforming the production and efficiencies in agriculture (Carolan, 2017b) with implications for global challenges such as food security and environmental concerns (Higgins et al., 2017). However, with the expansion of digital technologies used in agriculture and food production, there is evidence of emerging social and ethical issues (Bronson & Knezevic, 2016; Gardezi & Bronson, 2019). Social scientists suggest that digital technologies and innovations used in agriculture are not isolated but evolve within a constantly changing system that includes various technological, social, economic and institutional dimensions (Klerkx et al., 2012). Thus, taking an ecosystem view on technological change allows going beyond economic assessments to account for social and political outcomes from emergent technologies (W. Li et al., 2012). The literature shows that emerging concepts applied to study digital innovations in agriculture are developed on a foundation of digitisation or digitalisation technologies. The literature suggests that these two levels of digital technologies have different implications for taking an ecosystem view (Matt et al., 2015; Legner et al., 2017; Gray et al., 2013; Stock & Seliger, 2016). The literature has not analysed the conceptual impact of these concepts on stakeholder inclusion in the ecosystem. Also, the literature has not developed an approach to analyse the scope of their stakeholder inclusion of the concepts to assess their alignment with taking an ecosystem approach.

- **Developing a systematic stakeholder inclusion framework in the digital agriculture ecosystem**

  This article focuses on developing a framework for societal stakeholder mapping in the context of the digital agriculture ecosystem. The literature asserts that digital agriculture delivers benefits to society (Regan, 2019), and stakeholder inclusion can ensure the equitable distribution of the benefits to a broader range of societal stakeholders and avoid favouring powerful stakeholders (Higgins et al., 2017). To ensure the required equity, approaches such as Responsible Research and Innovation (RRI) have developed theories and methods relevant to the inclusion of stakeholders in innovation processes. However, methods are arguably underdeveloped in their application to the Agri-food context (Eastwood et al., 2019; Rose & Chilvers, 2018). Thus, scholars highlight the lack of methods to follow for stakeholder identification in the ecosystem other than "heterogeneous assemblage" (Carolan, 2020). The current approach to identifying stakeholders is based on snowballing techniques where the identified stakeholders introduce other stakeholders (Andrieu et al., 2019; Carolan, 2017a; Carolan, 2020; Klerkx et al., 2019; Higgins & Bryant, 2020). However, snowballing techniques identify the most immediate stakeholder groups but are not necessarily inclusive or reprehensive of the entire ecosystem. Such a practice can be prone to bias. Therefore, recent scholarship has emphasised the necessity of developing a more comprehensive and systematic approach to stakeholder identification for responsible innovation in digital agriculture that is less prone to bias and complements the current practice (Rose & Chilvers, 2018; Bronson, 2019; Phillips et al., 2019).

The identified gaps are discussed in the following four chapters. Each chapter adopts different perspectives and methodology to answer a specific dimension of the overall research question.

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Gender Dimensions of Digitalisation:
A comparison of Venture Capital backed start-ups across fields

ABSTRACT

The digitalisation of economic activities has given rise to much hope that it will lead to greater opportunities for women and a more ‘level playing field’ in the work place. On the other hand, there are concerns that the increasing success of the companies that are driving digitalisation might mean that the male-dominated culture of software companies is becoming more prominent and potentially reduces opportunities for women. This study investigates the gender distribution of key professionals in 8164 Venture Capital (VC) funded digital start-ups, as compared to information technology hardware and life sciences and biotechnology start-ups, as well as the impact of gender on VC funding. We find that, despite extensive advances in digitalisation over the past decade, women’s participation remains low and continues to have a negative relationship with VC funding in both digital start-ups and other start-ups. Thus, our findings suggest that the recent digitalisation is not ‘levelling the playing field’ on a broad scale and that companies and policymakers need to be proactive to design inclusive strategies to capture benefits from a diverse workforce in digital start-ups.

Keywords:
Venture Capital; Gender; digital start-ups; Digitalisation

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Dear reader, the authors used zero papers to develop this research. It means all the readings, note-taking, text synthesising, table preparations, commentation, documentations, and storage were conducted using digital devices and technologies. To keep this study green, please only print whenever necessary.

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The author

1. Introduction

Over the past decade, digital technologies have become dominating in every dimension of our daily lives and societies (Elia et al., 2014). They also provide the basis for rapid changes in entrepreneurial activities leading to economic change, societal transformation (Brynjolfsson and Saunders, 2009), and the emergence of digital entrepreneurship (Nambisan, 2017).

As digital technologies are transforming entrepreneurial activity, and economic activity more broadly, public and policy discourse have on the one hand raised the spectre of vast job losses, but on the other hand raised great expectations in terms of opportunities for individuals who have faced greater barriers entering into the labour market and into entrepreneurship specifically. In this context, digital entrepreneurship has been touted as a potential means by which to overcome the gender disparities documented throughout much of entrepreneurship literature (for a review of the discussion of gender and entrepreneurship see Ahl, 2006).

The goal of this study is to examine whether, indeed, the digitalisation of entrepreneurship is reflected in increased opportunities for women in managerial roles in digital start-ups (henceforth referred to as Digital). For comparison, we also investigate start-ups in information technology hardware (henceforth referred to as Hardware) and life sciences and biotechnology (henceforth referred to as Biotech) fields, as well as implications for access to VC funding.

1.1. Digital start-ups

The concept of digital start-ups implies a recently founded enterprise in which information technology plays a key role in developing competitive advantages. A range of definitions has been proposed, with substantially varying degrees of breadth. Some scholars define the concept of digital enterprise in terms of digital business models that trigger fundamental change (Veit et al. 2014). By this definition, most of the enterprises active in media, retail, financial services, and in logistics are adopting digital business models (Veit et al., 2014), Although this approach to the definition is comprehensive, it cannot clearly distinguish digital enterprises from traditional enterprises.

Other scholars take a more narrow approach based on the input and output of the enterprise. Andriushchenko et al. (2019) argue that digital enterprise business models necessitate a foundation of technological innovations such as cloud computing, big data, mobility and social networks and the final product offered by those enterprises becomes digital as well. Centrally, the success of such companies rests on the effective utilisation of digital technologies (Sánchez, 2017). Thus, from the input-output perspective, digital enterprises build on a digital foundation to process digital resources (i.e, internet, software, code etc.,) and deliver an important share of their services in digital formats (Bērziša et al., 2015; Sánchez, 2017).

Some scholars take this definition a step further by discussing the distribution channel in digital enterprises. Huang et al. (2007) argue that an enterprise is called digital only when its web portal is significant to its business activities and decision-making. In such an enterprise the business activities are conducted mainly through online content and web applications on the internet. The application of digital technologies in digital enterprises can transcend the channel of distribution of the enterprise to include all forms of interaction with the external environment. Thus, from the interaction perspective, a digital enterprise can be defined as an enterprise that conducts its buying and selling activities, customer services activities, interaction with business collaborators and other organisations through digital technologies (Turban et al., 2017).

A last approach is to define digital enterprises based on the types of assets held by enterprises. One objective of digital enterprises is to develop a digital structure and design and to utilise digital equipment for digital productions (Liu and Chen, 2010). Hence, Cho et al. (2019) argue that in their corporate value structures, digital enterprises possess comparatively more intangible assets and cash compared to traditional enterprises. Their value derives from the brand, knowledge and intellectual property, rather than the tangible assets forming the basis of traditional enterprises.

In this study, we adopt a definition closely associated with the input-output based approach (Bērziša et al., 2015; Sánchez, 2017). The expectation that Digital start-ups will provide a levelling field for women to engage in start-ups activities is based on the assumption that Digital start-ups can afford opportunities to not interact in physical formats with colleagues and customers. Where both inputs and outputs are in digital forms, one may assume that most activities can take place based on digitally-enabled transactions, thus providing opportunities to reduce the influence of various barriers discussed below. This definition includes the more narrow definition of Huang et al. (2007), and implies that most new companies developing software and services will meet this definition.

We consider Digital start-ups and, for comparison, start-ups from the Hardware and Biotechnology fields in this study. Digitalisation is also pervasive in these comparator start-ups, and these companies can be expected to substantially apply digital technologies in their respective value creation and value delivery processes. This implies that, from a technological perspective, they provide sufficient similarities for a meaningful comparison with Digital start-ups. However, in terms of gender implications of digitalisation, they exhibit fundamental differences with the concept of a digital start-up. First, according to Andriushchenko et al. (2019), the production foundation of Biotechnology and Hardware is heavily rested on hard technologies including machinery and laboratory equipment and their inputs and output include diversified intakes and not limited to digital resources like Digital start-ups (Bērziša et al., 2015; Sánchez, 2017). Also, Biotechnology and Hardware have a diversified network of supply and distribution of material goods, implying requirements for physical transactions with customers (Huang et al., 2007; Turban et al., 2017). Finally, Digital start-ups have substantially lower capital intensity than Biotechnology and Hardware start-ups (Liu and Chen, 2010; Cho et al., 2019). As discussed below, these characteristics can be expected to afford women greater opportunities, especially in the early start-up phases.

1.2. Women in digital start-ups

Many authors have pointed out the fact that “Founding a technology-based firm is commonly regarded to be a male domain” (Dautzenberg, 2012, p.79), an argument generally based on the low proportion of women among technology-based start-ups founders, as well as the conceptualization of entrepreneurial traits as stereotypically male (Cohoon et al. 2010), and potentially reinforced by gender differences in entrepreneurial motivations (Carter et al. 2003), occupational crowding in general (Aidis 2016), and the lack of inclusion of women in the imagining of technology sectors (Chau and Quire, 2018).

In the context of entrepreneurship in general, research has shown that the number and importance of female entrepreneurs has consistently increased over time (Haus et al., 2013) although globally, men are still about twice as likely to start a new venture as women (Hechavarría et al. 2018). Women are less likely to follow through on their intentions to their own companies (Shinnar et al., 2018), and there are gender differences in terms of the longevity of entrepreneurs’ engagement. Kalnins and Williams (2014) show that in some industries women-owned businesses are likely to outlast men-owned businesses, in many there are no significant differences, and in some other industries, men-owned businesses are likely to outlast women-owned businesses.

While participation is of course the basis of any involvement of women in start-ups, perhaps the most striking reflection of gender disparities has been observed with regards to funding, and specifically Venture Capital (VC) funding. There is extensive research documenting the substantive gender gap with regards to VC funding (Becker-Blease and Sohl, 2007, Bigelow et al., 2014, Brush et al., 2018, Coleman and Robb, 2009, Gompers and Wang, 2017, Robb and Watson, 2012, Sorgner et al., 2017, Zarya, 2018). Women are underrepresented among founders, executives and senior managers of VC funded companies (Aidis and Schillo, 2017), and are awarded fewer opportunities by VCs to present their pitches in a positive light (Kanze et al., 2018). Thus, if there is a broad levelling effect of digital technologies with regards to Digital start-ups, it would be important to see it reflected in the area of greatest gender disparity, i.e. VC funding.

1.3. Is there a digital advantage in participation in digital start-ups?

There is substantial discourse in both academia and the broader media landscape that suggests that digitalisation may lead to increased empowerment of women, and a more equal participation of women in labour markets, financial markets and entrepreneurship (Krieger-Boden and Sorgner, 2018, Dy et al., 2017). Predictions of job losses due to digitalisation tend to suggest that in many countries, women will be less likely to be replaced by machines than men, often times due to their relatively stronger involvement in jobs with higher education profiles, as well as the types of positions they hold in each job category (Krieger-Boden and Sorgner, 2018). This is also attributed to women’s statistically superior social skills, which may represent a comparative advantage in digital environments, especially if combined with higher education and advanced digital literacy (Krieger-Boden and Sorgner, 2018).

Digital entrepreneurship, specifically, has been widely suggested to level the playing field. Perceptions such as the “nature of the Internet having an open access and open standards essentially allows anyone to develop and share applications on the Internet” (Sussan and Acs, 2017, p.62) suggest that anyone, of any gender, may successfully engage in digital entrepreneurship. More specifically relating to gender and entrepreneurship, digital entrepreneurship may afford women more opportunities because visible markers of gender may be absent online, start-up costs and other barriers of entry are perceived to be lower, women may start businesses or contribute while working from home, and many transactions do not take place in person, effectively leading to ‘disembodiment’ of the transaction (Dy et al., 2017, Martin and Tiu Wright, 2005).

There is evidence from several contexts that digitalisation has been effective in increasing gender equality and empowering women. For example, Mallia and Windels (2011) conclude from interviews with advertising and marketing communications practitioners that the nature of the work in the context of digital advertising is such that more diverse teams are required and that women in this context have more positive workplace experiences than in traditional media contexts. Similarly, there is evidence that women may have an advantage on crowdfunding platforms (Johnson et al., 2018), or at least that some of the gender disadvantages are levelled (Gafni et al. 2015) – in stark contrast to VC funding (discussed below).

Following this literature, we propose Hypothesis 1a:

> *Hypothesis 1a: The participation of women is higher in digital start-ups as compared to other technology-based fields.*

Despite the examples of digitalisation leading to greater equality and women’s empowerment, authors also caution that many of the barriers women face in traditional businesses also apply to digitised contexts, including digital entrepreneurship (Krieger-Boden and Sorgner, 2018). Studying digital entrepreneurs and drawing on theory on intersectionality, Dy et al. (2017) conclude that offline barriers to meritocracy are also reflected online, and that systemic inequalities persist.

To contrast the positive examples above, there are also examples of niches where gender equality is not achieved through digital entrepreneurship. For example, Richter et al. (2017) focus on the sharing economy in several countries and find that it is dominated by men, in that male founders outnumber female founders.

Following this literature, we therefore also formulate the contrasting hypothesis:

> *Hypothesis 1b: The participation of women is lower in the digital start-ups, as compared to other technology-based fields.*

1.4. Is there a digital advantage in VC Funding?

While VC funding is not relevant to all start-ups, it is a key mechanism of financing new ventures in pharmaceutical biotechnology, and quite common in information and communication technology-related hardware. Increasingly, digital start-ups have also been receiving large sums of VC investments, and leading digital start-ups have been able to obtain substantial VC funding, both as a consequence of and precondition to the steep growth curves experienced by successful ventures (Sussan and Acs, 2017).

In these fields, external finance plays an often critical role, yet women have been documented to attract fewer and lower investments, both in form of VC and angel funding (Becker-Blease and Sohl, 2007, Bigelow et al., 2014, Brush et al., 2018, Coleman and Robb, 2009, Robb and Watson, 2012, Sorgner et al., 2017).

Research has consistently shown that the lower funding amounts are not a function of lower performance of women-led companies (Coleman and Robb, 2009; Robb and Watson, 2012; Guzman and Kacperczyk, 2019), but that they seem to be attributable to gender itself. A series of recent studies have investigated the mechanisms that lead to the differential outcomes for men and women. Balachandra et al. (2013) show that VC investors perceive women's pitches differently from men's pitches; Alsos and Ljunggren (2013) show that there are differences in how women and men signal legitimacy to VC investors; and Kanze et al. (2018) show that VC investors interact differently with women versus men. All of these studies suggest that the in-person interactions with investors play a large role, and, in combination with the Coleman and Robb (2009) findings, most likely the determining role in the gender funding gap. Although digital start-ups may operate in a 'disembodied' environment in their online client interactions – which may reduce gender gaps –, pitching to VC investors remains an in-person activity, suggesting that digitalisation is unlikely to level the playing field for women in the VC context.

There is some evidence that digital funding platforms are changing, if not levelling the funding playing field to some extent. Recent literature suggests that the gender funding gap may be more nuanced (Gafni et al. 2016) or even reversed (Johnson et al., 2018) in crowdfunding contexts. Typically, in crowdfunding campaigns, the identity of founders is disclosed, so this would not be a consequence of 'disembodied' interactions, but rather an indication of different behaviour by crowdfunding investors. However, this study is focused on VC funding, so it is likely these findings do not translate to the VC context.

Thus, we hypothesise that the gender gap in VC funding remains significant for digital start-ups:

> *Hypothesis 2: The proportion of women in leading positions in digital start-ups is negatively associated with the amount of funding received by companies.*

2. Materials and Methods

2.1. Data

The data for this study were drawn from CapitalIQ, a commercial financial database. The focus of this study is on young, VC funded companies in the digital space in North America and the advanced economies of Europe. We include information technology hardware (Hardware) and life science and biotechnology (Biotechnology) start-ups for comparison.

Start-ups were identified based on the industry classification provided by CapitalIQ. For the group of Digital start-ups, we included most sub-fields of the software industry, for example, artificial intelligence software, but also more established fields, such as customer relationship management software and general enterprise software. We excluded fields where software development is very closely associated with hardware components, such as Automation Products and Services. Further, we selected only companies founded in the last ten years, e.g. following Guo et al. (2019).

The resulting data set consists of 8164 companies with complete information in the variables studied, distributed across the relevant fields as shown in Table 1.

Table 1 Number of companies by field

Field	*Number of Companies*
Digital	2764
Hardware	1043
Biotechnology	4357

The data set includes public and private companies, operating independently or as subsidiary, with funding from Venture Capital firms– whether it be past, current or pending. It has been argued that digitalisation not only reduces the influence of gender barriers, but also geographic barriers.

Therefore, we include data from North American and European countries, which can be assumed to operate within economic and institutional frames. Table 2 shows the distribution of start-ups by these categories and highlights that privately held companies are predominant, and the majority of start-ups in this sample stems from the United States of America.

Table 2 Distributions of categorical variables by field

	Digital	*Hardware*	*Biotechnology*	*Total*
Company type				
Private Company	2720	1012	3997	7729
Public Company	44	31	360	435
Total	2764	1043	4357	8164
Country				
United States	2005	736	3420	6161
Canada	98	42	197	337
France	127	70	124	321
UK	199	71	241	511
Rest of Europe	335	124	375	834
Total	2764	1043	4357	8164

2.2. Methods

The focus of this study is on the gender distribution of professionals within VC funded companies. However, CapitalIQ does not provide gender data. Thus, our first analysis step consists of the identification of first names in a field describing professionals associated with the company. We then attribute gender based on first names using the R packages ‘gender’ and ‘genderizeR’. These packages are based on a subset of the US census data, which provides first names and gender.[1]

Our first research question can best be answered with descriptive statistics, comparing the number of women involved in companies in Digital start-ups to others. To answer our second research question, we conduct OLS regression analyses for each field, and compare the results across fields.

For both analyses, the key variables are as follows:

[1] While it is beyond the scope of this paper to thematise the distinctions between gender and sex, and ‘woman’ and female’ in detail, we have considered these distinctions in the design of the study. We refer to gender and ‘woman’, aiming to acknowledge the social roles typically expressed by individuals through their first names, and acknowledge that our methodology may lead to a small number of erroneous attributions of gender.

Amount of funding (ln): CapitalIQ provides the estimated value of the total funds raised through private placement transactions, in millions of U.S. dollars. The distribution of amounts is heavily right-skewed, so we use the natural logarithm of the amount in the calculations below. This is the dependent variable in the regressions.

Proportion of women: Using the gender identification obtained through the analysis of first names, we calculate the proportion of women as the number of women divided by the sum of the number of women and men. Names that could not be identified were eliminated from the analysis. Similar to Aidis and Schillo (2017) and Mallia and Windels (2011), we focus not only on the owners or founders of businesses but consider the involvement of women among the entrepreneurial team as a whole.

We add the following control variables to the regression analyses, following Eddleston et al. (2016) and Coleman and Robb (2009), among others.

Number of VCs: Companies often receive funds from more than one VC firm. This variable indicates how many VC firms are listed for each company.

Size: Although CapitalIQ contains several fields related to the number of employees of a company, the missing values in each one are extensive in the target sample for this study. Therefore, we used the number of professionals listed as a proxy.

Country: Our study focuses on the United States, Canada and the advanced economies of Europe. We therefore include a dummy variable for each country. In the regression below, the United States is the reference country.

Company Status: Our data set includes primarily privately held companies, but also some publicly traded companies. We include a dummy variable to control for potential effects on funding levels.

Age: CapitalIQ provides data on the incorporation year for each company. The age variable is formed by subtracting the incorporation year from 2019.

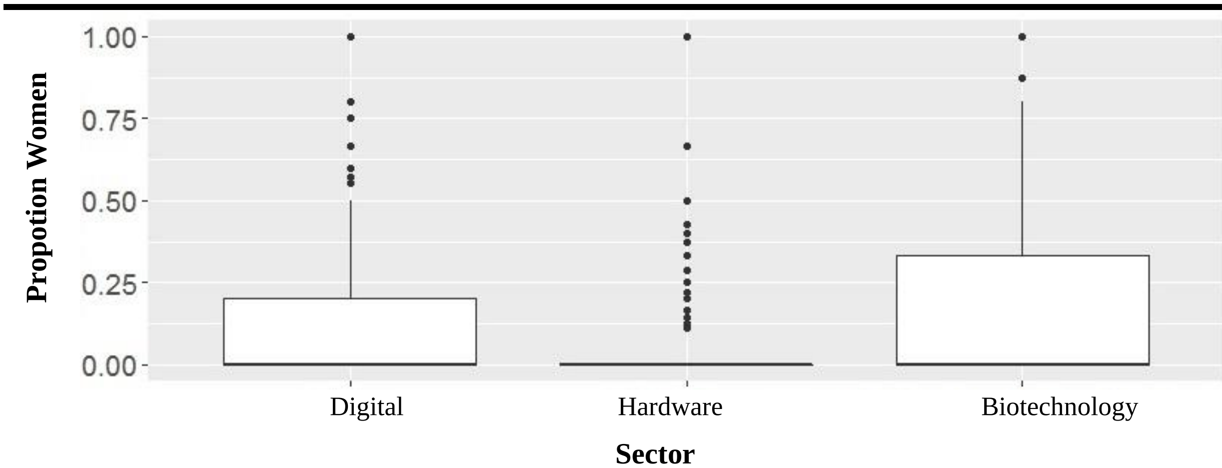
3. Results

To answer the first research question, we first present a series of results from descriptive analyses. Table 3 shows the proportion of women in companies in each of the fields investigated. In all three fields, the proportion of women in the VC funded companies in our sample is quite low, ranging from nine percent among Hardware start-ups to eighteen percent in Biotechnology start-ups. The focal Digital start-ups proportion is in between these numbers, with an average of twelve percent women. Figure 1 shows the distribution of the proportion of women as boxplot graphs for each field. It is notable that more than fifty percent of companies in all fields do not list women among their professionals, even among Biotechnology start-ups. Further, among Hardware start-ups, essentially any companies with women are considered outliers. For Digital start-ups companies have to have more than fifty percent women to be considered outliers, whereas in Biotechnology, even companies with seventy-five percent women would not be considered an outlier. An Anova test shows that the differences between fields are highly significant.

Table 3 Average proportion of women in companies by field

Field	*Proportion of Women (mean)*
Digital	12%
Hardware	9%
Biotechnology	18%

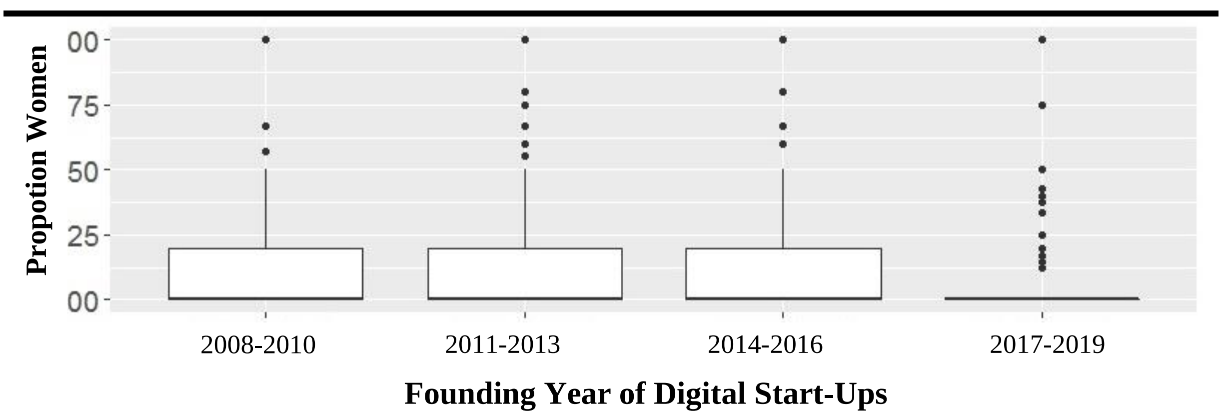
Figure 1 Boxplots of proportion of women in companies in different fields



With regards to Hypotheses 1a and 1b, separate tests show that there are significant differences in the proportion of women across fields, but we cannot conclude that Digital start-ups have categorically more or fewer women in leading positions than other technology-based fields.

Figure 2 shows that the proportion of women is generally consistent across firm age groups, with the exception of very young firms. The third quartile for Digital start-ups is around twenty per cent. However, Digital start-ups less than two years of age tend to have much lower proportions of women. This suggests low levels of inclusion of women among the early professionals and founders of the Digital start-ups. Beyond the initial stages, the participation of women increases, but does not seem to change much over time after the initial expansion phase. This trend is different in the other fields (not shown in graphs), Hardware essentially not showing much representation of women at any age, and Biotechnology start-ups showing just slightly lower initial involvement of women, then a peak for start-ups between three to nine years, and a slight drop for older start-ups.

Figure 2 Boxplots of proportion of women in age groups of Digital start-ups.



Tables 4 and 5 show descriptive variables and correlations of the numerical variables in the data set respectively.

Table 4 Descriptive Statistics of quantitative variables

Variable	*Number*	*Mean*	*St. Dev.*	*Min*	*Max*
Size	8,164	3.703	2.233	1	10
Number of VCs	8,164	3.509	4.288	0	44
Proportion of women	8,164	0.148	0.246	0	1
Age	8,164	5.678	2.264	0	9
Amount of funding (ln $M)	8,164	1.132	2.190	-5.809	6.800

Table 5 Correlations of quantitative variables

	Amount of funding (ln $M)	*Proportion of women*	*Number of VCs*	*Age*	*Size*
Amount of funding (ln $M)					
Proportion of women	0.005				
Number of VCs	0.544	0.044			
Age	0.091	-0.034	0.103		
Size	0.387	0.119	0.291	0.197	

Table 6 presents the results of OLS regressions, with the amount of external funding as the dependent variable (in ln($million)). We present separate regressions for each field.

Table 6 OLS Regression Results; Dependent Variable: Amount of Funding ln ($M)

Variable	Dependent Variable: Amount of Funding ln ($M)		
	Digital	Hardware	Biotechnology
Proportion of Women	-0.070***	-0.061*	-0.049***
Number of VCs	0.497***	0.497***	0.456***
Size	0.276***	0.231***	0.241***
Geographic Location (reference: USA)			
Canada	-0.034*	-0.034	-0.017
France	0.010	0.003	0.021
Rest of Europe)	-0.042**	-0.022	-0.015
UK	-0.030*	-0.006	-0.012
Age	-0.011	0.034	-0.020
Private Company (ref: Public)	-0.033*	-0.079**	0.032*
Constant	0.000***	0.000***	0.000*
Observations	2,764	1,043	4,357
R2	0.398	0.359	0.343
Adjusted R2	0.396	0.354	0.342
F Statistic	202.116*** (df = 9; 2754)	64.344*** (df = 9; 1033)	252.534*** (df = 9; 4347)
Note:			*p<0.1; **p<0.05; ***p<0.01

The models explain reasonable levels of variance in VC funding received: The adjusted R^2 values range from 34.3% for Biotechnology to 39.6% for Digital start-ups. The coefficients show that for all the three groups of start-ups, the proportion of women has a significantly negative, albeit relatively small impact on the amount of Venture funding received by start-ups. Between the sampled fields, the negative relationship is strongest for Digital start-ups (β= -0.070; $p<0.01$), followed by Hardware (β= -0.061; $p<0.1$), and Biotechnology start-ups (β= -0.049; $p<0.01$). We thus find evidence in support of Hypothesis 2.

For all the three, the number of VCs has the highest coefficients (β=0.456 to β= 0.497; $p<0.01$). Second to the number of VCs, size has the second-highest coefficient (β=0.231 to β=0.276; $p<0.01$).

For all the three fields, the age of the start-ups is not statistically significant. Company type, i.e. public versus privately held companies, is significant in all fields, but Digital and Hardware start-ups that are privately held are associated with lower levels of funding, while privately held Biotechnology start-ups are associated with higher levels of funding than public companies.

Finally, the geographic location of Hardware and Biotechnology start-ups is not significant with regards to their level of VC funding. However, for Digital start-ups, geographic location is a significant variable, with all considered countries or regions except for France showing significantly lower amounts of VC funding (Canada: β=-0.034; UK: β=-0.030; Rest of Europe: β=-0.042). This finding is contrary to the notion that the digital nature of the foundational technologies of start-ups levels the playing field in a broad sense, as will be discussed in the following section.

4. Discussion

Overall, the results of this study suggest that it is unlikely that digital entrepreneurship has an extensive levelling effect that would make gender irrelevant in the context of Digital start-ups. Thus our results are more aligned with Krieger-Boden and Sorgner (2018) and Dy et al. (2017), who state that "contrary to popular suggestion, systemic inequalities do not disappear when transfigured through the medium of the internet", rather than the somewhat levelling effects observed by Mallia and Windels (2011), Johnson et al. (2018) and Marom et al (2015).

Our findings do show that there are differences between the technology fields with regards to the gender gap, as might be expected based on education trends and on overall work force distribution within these sectors, irrespective of companies' start-up status. Biotechnology start-ups have on average higher inclusion of women in leadership teams than Hardware start-ups. Digital start-ups lie in between these two fields. In addition, we show that these trends have not changed noticeably over the past ten years, i.e. during the period of intensifying digitisation and digitalisation.

In fact, our analysis of changes over time reveals a dimension of gender gap that is rarely addressed: Digital start-ups tend to only integrate women into the leadership team only after the first two years. This suggests women are rarely involved in the early start-up activities, which typically reward founders and exacutives who join early with ownership shares. This implies that the women who eventually join start-ups will likely not benefit from the growth of the start-ups to the same extent as the male founders and early leaders.

Thus, our evidence shows that digitalisation is not ‘levelling the playing field’ on a large scale, and points to additional gender gaps. Given the relatively broad definition employed in our study, it is possible that there are niche areas, such as the digital advertising area studied by Mallia and Windels (2011), where digitalisation is levelling the playing field. Future studies would do well to investigate the sub-areas of the field.

With regards to the level of VC funding, the involvement of women in leadership remains associated with lower levels of funding in all fields considered, and significantly so. This finding is similar to that of earlier studies (e.g. Robb and Coleman 2010), suggesting little change over time. For Hardware and Biotechnology start-ups this effect is in the order of magnitude of the company type (public/private), for Digital start-ups this effect is more pronounced than company type and geographic effects. Thus, instead of a level playing field, we are finding more pronounced disadvantages for teams with more women in Digital start-ups in terms of their ability to secure large amounts of VC funding as compared to those in other fields.

In addition to the focal variables, there also is a notable finding with regards to the geographic control variables. We find that geography is not significant with regards to the amount of VC funding for Hardware and Biotechnology start-ups. However, for Digital start-ups, Canada, the UK and the Rest of Europe show lower levels of funding as compared to the United States, only France is not significant in comparison.

It is important to note that our findings do not imply that the performance of firms with high percentages of women is lower than that of firms with low percentages of women (Robb and Watson, 2012; Guo et al. 2018; Ewens and Townsend, 2020). Equally important, Marlow and McAdam (2013) stress that constrained performance is not synonymous with under-performance. However, in the context of VC funding, the lower amounts of funding provided to companies with more women suggest that there are constraints on the resources side that are not likely to be of the entrepreneurial team’s choosing, as they expanded the effort of seeking VC funding in the first place.

The main limitations of this study are a function of the data available in CapitalIQ. Firstly, the focal variable in this study, gender was not available and had to be derived using an R package based on a subset of the US Census data. While this package delivers excellent results for names that are common in the United States, the gender identification performs less well for uncommon names, which may introduce a bias in terms of professionals not born in North America. Future research should attempt to address this issue, but will likely have to rely on advances by computer scientists working on the topic (e.g. Karimi et al., 2016).

A further limitation is the definition of industries in CapitalIQ, which are not very detailed and may in some cases group digital and more traditional start-ups. For this study, we have explored a range of different definitions and groupings not presented here. The results seems to be quite robust and independent of variations in inclusion criteria. In addition, data on the education of individuals is not consistently available.

An opportunity for future research is that CapitalIQ provides information on job functions. Aidis and Schillo (2017) have shown that gender representation differs between the job categories of senior executives, senior managers, and founders. Future research could establish whether the CapitalIQ data can be used to differentiate between these categories.

5. Conclusions

Addressing the widely discussed hope that digitalisation can contribute to levelling the playing field for women in Digital start-ups, this study presents evidence relating to women's involvement in digital firms, and to their access to funding. We show that, while Digital start-ups have on average more women involved than Hardware start-ups, there are far fewer women involved than in the Biotechnology field, for example. Beyond participation, we also find that the involvement of women in start-ups is associated with lower amounts of VC funding for the firms, and this negative effect is in fact stronger for Digital start-ups than for Hardware or Biotechnology based start-ups. Our analyses also highlight that, in Digital start-ups, women seem to join the company after two or three years, thus raising concerns that they will benefit less from the growth of the company – a finding that should be investigated in more detail in future studies.

Our findings that there is no broad effect at the level of technology fields seem robust at this time, and suggest that the previous findings of positive effects in specific technology areas (Mallia and Windels, 2011) and crowdfunding (Johnson et al., 2018) cannot be generalised to expect a levelling of the playing field through digitalisation across the board.

This study has important implications for current public and policy discussions on gender in digital entrepreneurship. It shows that the concerns raised about the gendered workplace culture in Silicon Valley may be more broadly relevant, that the software and digital fields in general have low participation of women, that women entrepreneurs are not granted the same resources as male entrepreneurs, and that women are likely to benefit less from their involvement in Digital start-ups as they tend to join after the founding stages.

While politicians and policy developers may hope for digitalisation to have a levelling effect with regards to gender in entrepreneurship, our study suggests that this cannot be assumed to automatically be the case. Of course, there is evidence from prior studies that in specific areas, such as digital advertising (Mallia and Windels, 2011) and crowdfunding (Johnson et al., 2018), digitalisation may lead to increased opportunities for women. However, in other fields this is not the case. As observed by Dy et al. (2017) and expressed by Krieger-Boden and Sorgner (2018), "the same barriers and deficits that obstruct women's current advancement in many countries may deprive them from many beneficial opportunities in the digital age, including new entrepreneurial opportunities." Our study thus echoes the call of Leitch et al. 2018 for deeper consideration of policy implications of gender in entrepreneurship, and the need to carefully articulate strategies that are tailored to alleviate gender effects within entrepreneurship ecosystems (Coleman et al. 2019), including digital entrepreneurship ecosystems.

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Digital Technologies and Social Value in Corporate Social Media Communications

Abstract: This study investigates the relationship between the communication of two levels of digital technologies and the communication of social value at the enterprise level. Conceptually, digital technologies can enhance interaction with the external environment. The study examines whether such an impact is also detectable through corporate communication. The study approaches the communication of digitisation and digitalisation as two predictors and then examines their impact on the communication of three themes of social values, including stakeholder engagement, social inclusion, and ethics. The study is conducted based on keywords analysis obtained from tweets using the case of the agri-food sector in Canada. The analysis shows that the communication of a higher level of digital technologies (digitalisation) could be associated with a higher level of social value communication on the Twitter platform.

Keywords: Digitisation, Digitalisation, Digital Transformation, Social Value, Communication, Agri-food

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Dear reader, the authors used zero papers to develop this research. It means all the readings, note-taking, text synthesising, table preparations, commentation, documentations, and storage were conducted using digital devices and technologies. To keep this study green, please only print whenever necessary.

Many thanks,
The author

1. Overview

Since the beginning of the third millennium, scholars have indicated the influence of digital technologies would go beyond economic outcomes (Stamoulis & Martakos, 2001). At the conceptual level, the role of digital technologies in transforming societies and delivering social and environmental well-being is acknowledged (Linkov, Trump, Poinsatte-Jones, & Florin, 2018). These technologies are regarded as the backbone of social transformations that directly and openly contribute to the living quality of the society (Fromhold-Eisebith, 2017). Also, it is argued that digital technologies can be used for designing business models to allow the enterprise to be 'doing good' and 'doing well' (Täuscher & Abdelkafi, 2018). Furthermore, digital platforms impact empowering societies through accessible and affordable means. For example, by giving access to educational platforms, they enhance the skills of the individuals and provide new job opportunities (Azeiteiro, Bacelar-Nicolau, Caetano, & Caeiro, 2015); (Fromhold-Eisebith, 2017). This means digital technologies are not only capable of delivering economic value but also of having a positive influence on fulfilling the expectation of the societal stakeholders (Jovanović et al., 2018). Digital technologies can lead to innovation in areas such as productivity, value creation, and new ways of interacting with customers and stakeholders (Matt, Hess, & Benlian, 2015). Thus, digital technologies are capable of delivering value to a broad spectrum of stakeholders in areas such as reducing poverty, improving public health, and increasing food production (Linkov et al., 2018). Recent studies show that in societies with higher digital technology adoption, human well-being is better satisfied, and there is an overall positive relationship between digital technologies and Hofstede's social components (Jovanović et al., 2018).

Today, enterprises in almost all industries have developed and implemented initiatives to benefit from digital technologies leading to significant socioeconomic transformations in our societies (Matt et al., 2015). However, like any transformation in societies, digital technologies also may have socially detrimental impacts, for example, by reinforcing social inequalities (Riaz, 2015). To avoid such a detrimental impact, enterprises are required to observe social value consideration in their strategic design (Cuthill, 2010). Addressing this challenge requires strategic alignment between the societal stakeholders, such as the government, enterprise, and individual stakeholders (Manda & Ben Dhaou, 2019). Thus, the challenge faced by enterprises is shifting from sheer consideration and measuring their impact on society to how to deliver overall positive value to all stakeholders (Epstein, 2018). The notion of overall positive value entails attending to critical topics like human and environmental well-being, society engagement, and inclusion of all groups in society (Axelsson et al., 2013). At the enterprise level, designing actionable social indicators to monitor different performance areas constantly is a possible answer to such a challenge. This process conceptually can occur by embedding non-financial indicators in the enterprise's objectives (Kocmanová & Šimberová, 2014), and by interactively monitoring their indicators towards the social objectives (Doyle & Perez-Alaniz, 2017). To be effective, these strategies and indicators need be designed to encompass the expected value of the respective stakeholders (Boström, 2012). However, measuring and monitoring social value at the enterprise level has a complex nature. First, there is a lack of consensus on the meaning of social value at the enterprise level (Eizenberg & Jabareen, 2017). Second, the nature of social issues evolves over time, requiring continuous reviewing and redefining of performance indicators (Epstein & Roy, 2001); (Axelsson et al., 2013). Third, the concept involves attending to stakeholders with competing interests (Epstein, 2018). Fourth, the concept of value is influenced by local interpretation (Boström, 2012); (Doyle & Perez-Alaniz, 2017). Overcoming this challenge requires constantly setting trade-offs between different objectives (Epstein, 2018). This leads to the improbability of designing a standardised approach for delivering value to stakeholders (Epstein, 2018). Therefore, unlike other strategic initiatives, even those enterprises that have developed a systematic method for stakeholder value delivery, their operational strategy is partially designed based on a specific theme (for example, inclusion and diversity) and, or related to a particular case study.

Acknowledging the constraints of measuring social value, we focus on a specific aspect of social value communication at the enterprise level. Instead of measuring the direct performance, we investigate the impact of communication of digital technologies on the developed communication of social value by the enterprise. We aim to answer two questions. First, whether the conceptual relationship between digital technologies and social value could be statistically detected and meaningfully measured by analysing corporate communication. Second, to investigate whether a higher level of digital technologies (digitalisation) plays a role in increased social communication at the organisation level. Such a possibility is conceptually discussed in the literature in terms of the impact of digitalisation on changing the perception of the source of value and dissolved enterprise boundaries. The current study empirically tests such a possibility.

This paper is structured as follows. First, we review how different levels of digital technologies are measured and how each level transforms the interaction of the enterprise with its external environment. Second, we review Corporate Social Responsibility (CSR) literature to understand how the concept of social value is measured at the enterprise level. Third, we group the measures into themes and apply them as keywords to determine the communication of social value on social media. Increased communication about a group of measures (digital or social) is used as a proxy to measure the level of communication of a specific theme. Finally, the relationship of communication between two concepts of digital technologies and social value is tested by analysing weighted keywords from both digital and social domains. The analyses are based on keywords extracted from tweets from originations involved in the Canadian Agri-food ecosystem.

2. Literature review

The study is conducted based on the analysis of social value communication on social media. Engaging in communication with stakeholders is considered an act of social value at the enterprise level (Schueth, 2003). Moreover, communication of social value is acknowledged as a criterion of social awareness in emerging digitally-enabled businesses (Novak, 2005). As a result, building on arguments such as the signal theory, scholars highlight the importance of communication in the context of social value. The motive of communication is asserted as the tendency of enterprise management to communicate desired social performance to gain social credit and attract economic value (Chabachib, Fitriana, Hersugondo, Pamungkas, & Udin, 2019); (Chang, Yeh, & Li, 2020); (Machmuddah, Sari, & Utomo, 2020). For example, there is evidence that social value communication on social media can be positively associated with attracting funds on crowdfunding platforms (Wahjono, Marina, Sezeli, & Mahardika, 2019). On the other hand, digital platforms such as social media provide a dynamic and real-time environment for stakeholders to communicate their expectations of value (Ye, Zhao, Nguyen, & Wang, 2020). However, although communicative theories, such as the signalling theory, are discussed and applied in areas such as strategic management and entrepreneurship (Connelly, Certo, Ireland, & Reutzel, 2011), the communication of social value may be biased towards deliberately focusing on positive communication (Carlini, Grace, France, & Lo Iacono, 2019).

The following section discusses how digital technologies evolved to influence how the enterprise engaged with its respective environment and the necessity of communicating with stakeholders.

Then, we list the corresponding digital measure for each level of evolution. These measures are used as keywords to analyse the communication of digital technologies.

2.1. Waves of digital technology evolution

Digital technologies evolve over time with distinctive characteristics for each technology wave. The literature documented three waves of evolution. The first wave is known as *digitisation,* where digital technologies replaced physical processes and led to a higher level of automation in the work environment. The digitisation wave replaced analogue technologies with digital technologies version (Stock & Seliger, 2016); (Jovanović et al., 2018); (Legner et al., 2017). Digitisation strategies aimed to improve efficiency through enhancing internal processes such as the implantation of Information Technology (IT) systems (Matt et al., 2015); (Stock & Seliger, 2016); (Legner et al., 2017); (Jovanović et al., 2018). The second technology wave is known as *digitalisation,* where digital technologies prepared the ground for developing new internet-based communicative technologies that led to new types of value creation, such as e-commerce, or new intermediaries (like e-payments; the author) (Legner et al., 2017). Digitalisation aimed to improve efficiency by enhancing external interactions of the business models (Matt et al., 2015); (Stock & Seliger, 2016); (Legner et al., 2017); (Jovanović et al., 2018). Digitalisation strategies are expected to identify and apply the best practices of digital systems for overcoming external challenges, including the expectations of their stakeholders (Linkov et al., 2018). The third wave is known as *digital transformation*, where a combination of advancing digital technologies is applied to develop entirely new business models (Legner et al., 2017). Digital transformation refers to fundamental changes with implications for the external environment (Matt et al., 2015); (Stock & Seliger, 2016); (Jovanović et al., 2018). Digital transformation is particularly important from the enterprise perspective as it enables interaction with changing environments. Digital transformation emphasises socioeconomic changes driven by digital technologies in society (Dini, Iqani, & Mansell, 2011); (W. Li, Badr, & Biennier, 2012). However, as explained in the next section, we argue that digital transformation is still at a conceptual level.

Hypothesis 1: There is a relationship between increased communication of digital technologies and communication of overall social value.

2.2. Enterprise social engagement in digital waves

2.2.1. Digitisation

Digitisation started with IT development and generally aimed to improve efficiency (Legner et al., 2017). It can take different forms, including the use of the internet, software, telecommunication technologies, investing in technology infrastructures and robotics, and online sales (Calvino et al., 2018). Approaching digitisation resulted in agility in responding to the change and consistency in operations (Imgrund, Fischer, Janiesch, & Winkelmann, 2018). However, IT strategies applied in the digitisation wave focused on the IT infrastructure. Those strategies approached IT as an internal system of efficiency and automation (Matt et al., 2015). This IT approach separated the enterprise's external environment and its IT capabilities (Legner et al., 2017). This internalised approach is criticised for embedding a misalignment between external business objectives and IT systems (Legner et al., 2017). Such an approach limited the impact of IT-driven innovations on business development and engagement with the external environment (Matt et al., 2015). Also, the IT system-centric approach provided a platform for technology application within the enterprise (i.e., automation) without accounting for transforming products, processes, and structure to engage with the external environment (Matt et al., 2015). Hence, the impact of IT technologies in the digitisation wave is poorly applied to the engagement with the external environment. Therefore, digitisation technologies have a limited impact on motivating external communication.

Hypothesis 2: The concept of digitisation is concerned with internal efficiencies of the enterprise and is not relevant to measuring the external communication of social value.

2.2.2. Digitalisation

Digitalisation requires the enterprise to develop comprehensive digital solutions and strategies that consider external opportunities, risks and value creation based on digital capabilities (Imgrund et al., 2018). As digital technologies advanced, they became more user-friendly and accessible at a lower cost to greater divisions of society (Legner et al., 2017). Consequently, enterprises began to develop customer interface platforms for interacting with external stakeholders such as end-users (Matt et al., 2015). The ability to interact with external stakeholders challenged the enterprise to start developing strategies for utilising the external opportunities and perceiving the external environment, including customers, as a source of value (Gray et al., 2013); (Stock & Seliger, 2016). To address the expectations in this new environment, the internalised nature of IT and IT strategies had to be redesigned to accommodate for new enterprise structure, new forms of interaction, and innovation (Legner et al., 2017). This change in approach led to the development of systems that prepared the ground for an open socio-technical environment that combines economic, technological, and social domains, including the interaction with societal stakeholders (W. Li et al., 2012); (Legner et al., 2017); (Pinzone et al., 2018); (Manda & Ben Dhaou, 2019). These systems also required the enterprise to build new capabilities and a comprehensive approach to adapting different technology systems while dealing with multiple stakeholders (W. Li et al., 2012). As a result, digitalisation enhanced the enterprise's flexibility, agility, and responsiveness by simultaneously aligning its internal components such as operations, corporate strategy, and IT structures to the external technological and social changes (Imgrund et al., 2018). This interaction with the external environment (customers, industry, and various societal stakeholders) created a scope for engaging with the external environment for innovative value creation (W. Li et al., 2012); (Legner et al., 2017). It also assisted in developing new human capital and managerial competencies for such an interaction (Weber, Butschan, & Heidenreich, 2017) and in preparing the ground for a power shift and power share with other stakeholder groups (Legner et al., 2017). As a result, interacting with the external environment and various stakeholders on an organised and timely basis promoted innovation and enhanced the level of competencies of the enterprise and value delivery (W. Li et al., 2012); (Trantopoulos, von Krogh, Wallin, & Woerter, 2017). Hence, the impact of advanced digital technologies in the digitalisation wave is adequately applied to engage with the external environment. Therefore, digitalisation technologies have a positive impact on motivating external communication.

Hypothesis 3: The concept of digitalisation is associated with enhanced communication of the interaction with the external environment of the enterprise and is concerned with social value.

2.2.3. Digital transformation

As a multifaceted phenomenon, digital transformation has many definitions, including an integrated enterprise environment for value delivery and transforming value-adding processes, profitability, key business structures and managerial concepts (El Hilali & El Manouar, 2018). Digital transformation is argued to be capable of fundamentally transforming the perception of the source of value that has begun with approaching the external environment in the digitalisation wave (Gray, El Sawy, Asper, & Thordarson, 2013); (Woerner & Wixom, 2015); (Legner et al., 2017); (Nambisan, 2017). Also, it is capable of transforming the expectations of the value of individuals and stakeholder groups on efficiency, value creation, and uncovering new opportunities and risks, leading to a loop of mutual influence and impact between the enterprise and its external environment (Legner et al., 2017); (Jovanović et al., 2018). As a result, the impact of digital transformation can initiate transformations in the current reality of society perceived by various stakeholder groups in different industries (Hess, Matt, Benlian, & Wiesböck, 2016); (L. Li, Su, Zhang, & Mao, 2018).

However, digital transformation is argued to be aligned and taking place in the context of advanced digital technologies such as Artificial Indigence (AI) (Brock & Von Wangenheim, 2019); (Ruiz-Real, Uribe-Toril, Torres, & De Pablo, 2021). Technologies like AI are applied to constantly monitor stakeholders' needs by analysing stakeholders' expectations (Ruiz-Real et al., 2021). Such an approach requires designing digital transformation strategies to redefine decision-making activities between humans and AI toward computerised decision-making (Jarrahi, 2018). Although digital technologies are being widely deployed in business models and stakeholder value delivery, currently not all actors have implemented AI decision-making strategies. For example, such a transformation is being developed in sectors like agriculture, but digital technologies have not replaced human reasoning (Wolfert, Ge, Verdouw, & Bogaardt, 2017). Thus, we argue the concept of digital transformation is still evolving and not fully operationalised in most of the current business models and activities. Thus, we exclude digital transformation from the analysis, leaving only the digitisation and digitalisation measures.

Notably, digitisation and digitalisation are often used interchangeably. The definitions of digitisation and digitalisation are applied to categorise the technologies. For example, when a specific technology is related to internal efficiency, with limited impact on the external environment, it is listed under digitisation. Similarly, those technologies used to interact with the external environment in value delivery are listed under digitalisation.

Table 1. digitisation and digitalisation terminology

Digitisation technologies	• 3D Printing (İnel, 2019); (Nagano, 2019) • Adaptive Production And Logistics Planning (Stich, Zeller, Hicking, & Kraut, 2020) • Analysis of Production and Quality Data (Stich et al., 2020)

	• Automated Machinery (İnel, 2019); (Nagano, 2019) • Computer Vision, Speech Recognition (Mendhurwar & Mishra, 2021) • Condition Monitoring (Stich et al., 2020) • Digitalization of Analogue Data (Blštáková, Joniaková, Jankelová, Stachová, & Stacho, 2020) • Digitalization of Physical Documents (Mergel, Edelmann, & Haug, 2019) • Document Management System (Stich et al., 2020) • Electronic Data Interchange (Stich et al., 2020) • Enterprise Software (Bertschek, Ohnemus, & Viete, 2018) • Implementation of ERP (Stich et al., 2020) • InMemory Databases (Hoberg, Krcmar, & Welz, 2017) • IT integration (Stich et al., 2020) • Process Management (Stich et al., 2020) • Robotic (İnel, 2019); (Nagano, 2019) • Systematic Analysis of Errors and Scrap (Stich et al., 2020)
Outcome of digitisation	• Additive Manufacturing (Junge, 2019) • Automation (Junge, 2019); (Nagano, 2019) • Autonomy (Junge, 2019) • Digitize Processes (workflows or procedures within an organization) (Mergel et al., 2019) • Paperless production (Stich et al., 2020)
Digitalisation technologies	• Artificial Intelligence (Hoberg et al., 2017); (İnel, 2019); (Mendhurwar & Mishra, 2021); (Nagano, 2019) • Big Data Analytics (Bertschek et al., 2018); (Blštáková et al., 2020); (Hoberg et al., 2017);(Mendhurwar & Mishra, 2021); (İnel, 2019) • Blockchain (Hoberg et al., 2017); (Junge, 2019) • Cloud Computing Technologies (Bertschek et al., 2018); (Hoberg et al., 2017); (Junge, 2019); (İnel, 2019); (Nagano, 2019) • Cybersecurity (İnel, 2019); (Nagano, 2019) • Deep Learning (Mendhurwar & Mishra, 2021) • Digital Security (Hoberg et al., 2017) • GDPR (customer protection) (Blštáková et al., 2020) • Internet of Things (Hoberg et al., 2017); (Nagano, 2019); (İnel, 2019); (Stich et al., 2020) • Machine Learning (Mendhurwar & Mishra, 2021) • Mobile Apps (Bertschek et al., 2018); (Hoberg et al., 2017); (Nagano, 2019) • Natural Language Processing (Mendhurwar & Mishra, 2021) • Novel Interfaces (Hoberg et al., 2017) • Social Media (Bertschek et al., 2018); (Hoberg et al., 2017); (İnel, 2019); (Nagano, 2019) • Virtual and Augmented Reality (Junge, 2019)
Outcome of digitalisation	• Cyber-Physical Systems (Junge, 2019) • Digitize Relationships (Mergel et al., 2019) • Digitize Services (Mergel et al., 2019) • E-Commerce (sales over the internet) (Bertschek et al., 2018) • Hyper-Personalization (Moroz, 2018) • Industry 4.0 Projects (Bertschek et al., 2018) • Predictive Analytics (e.g., in marketing) (Blštáková et al., 2020) • Mobile Services (İnel, 2019) • Real-Time Capabilities (Junge, 2019) • Advanced Analytics (e.g., feedback) (Blštáková et al., 2020); (Junge, 2019); (Nagano, 2019) • Tracking & Tracing (Stich et al., 2020) • Innovation Community (Stich et al., 2020)

2.3. Challenging nature of conceptualising social value at the enterprise level

As discussed earlier, the impact of embedding digital technologies in the enterprise's value delivery model on the social dimension is acknowledged in literature (Loebbecke & Picot, 2015); (Pappas, Mikalef, Giannakos, Krogstie, & Lekakos, 2018); (Demir, 2021); (Brynjolfsson, Wang, & Zhang, 2021). To examine the impact of communication of digital technologies on communication of social value, we review the meaning of social value delivery at the enterprise level and how it is measured in the literature.

Over the past decades, many theoretical frameworks and concepts have aimed to explain different dimensions of value delivered to society in the business context. For example, the impact and business relation with society (Preston & Post, 1975), the concept of Corporate Social Performance (Archie B Carroll, 1979), (Wartick & Cochran, 1985), Corporate Social Responsibility (CSR1) and Corporate Social Responsiveness (CSR2) (Wood, 1991); (Clarkson, 1995); (Swanson, 1995); (Aguilera, Rupp, Williams, & Ganapathi, 2007), stakeholder theory (Donaldson & Preston, 1995); (Mitchell, Agle, & Wood, 1997), the Triple Bottom Line (TBL) (Elkington, 1997); (Govindan, Khodaverdi, & Jafarian, 2013); (Onat, Kucukvar, & Tatari, 2014) and shared value (M. Porter & Kramer, 2011) are only a few such examples. The justifications included a wide spectrum from normative, instrumental, and compliance reasons to set a shared value with the society. However, despite the increasing demand for social value through sustainable practice, scholars argue about the dearth of theory and the absence of consensus on the meaning of social value, particularly at the enterprise level (Eizenberg & Jabareen, 2017). Yet, the tendency of the concept to evolve over time (Epstein & Roy, 2001); (Axelsson et al., 2013) and the tendency of the concept to differ based on the society (Boström, 2012); (Doyle & Perez-Alaniz, 2017) add to the complexity of formulating a clear definition for social value. As a result, the literature on social value seems to have taken a macro-level approach. At this level, the concept relates to broad objectives such as achievements in the ecological and economic dimensions (Vallance, Perkins, & Dixon, 2011). At this level, the primary focus of social value is delivering solutions for broad notions such as fairness, health, and well-being (Marshall, McCarthy, Heavey, & McGrath, 2015). From this perspective, social value is concerned with institutions, policies, and factors that empower all stakeholders of the society to fulfil their potential and prosper (Bilbao-Osorio et al., 2013). Therefore, social value definitions are designed comprehensively to capture multifaceted issues of societal value, such as ethics for human survival and growth (Mani et al., 2016), but purposefully kept vague to accommodate including objectives such as achievements in the ecological and economic dimensions (Vallance et al., 2011). This ambiguity of the definition makes the concept comprehensive at the macro-level but not necessarily operationalisable and measurable at the enterprise level (Marshall et al., 2015); (Doyle & Perez-Alaniz, 2017). Therefore, at the enterprise level, the approach to social value is based on the practical understanding of plausibility and current political dimensions rather than being developed on a conventional theoretical foundation (Griessler & Littig, 2005). Scholars assert that one reason for taking a practical approach rather than theory development is that the approach to social value delivery at the enterprise level is influenced by definitions designed at the macro-level (Govindan et al., 2013). However, vague and broad definitions of the concept have not rendered the demand for socially sustainable business practice. On the contrary, such a demand puts the business in a position of taking steps beyond simple compliance with rules or wealth creation (Mazutis, 2014). Reciprocally, enterprises are becoming more sensitive to social issues and stakeholders' concerns driven by humanitarian and environmental factors, as well as external pressures and regulations (Epstein, 2018). Therefore, as explained in the next section, the approach of practicality and plausibility is operationalised by applying a thematic approach to social value.

2.4. A thematic approach to measuring the social value

The classic social and sociology theories are preoccupied with themes about concepts such as cohesion, stability and integration of communities (Magee, Scerri, & James, 2012). This approach is also implemented in measuring sustainable social value in the business context, where most of the measures are applied within themes (Landorf, 2011); (Murphy, 2012); (Magee et al., 2012); (Staniškienė & Stankevičiūtė, 2018). In this approach, instead of addressing one comprehensive and complex concept, such as social value, different facets of this concept are categorised under specific themes. Thus, although social sustainability remains a matter of high-level policymaking (Axelsson et al., 2013), the concept is widely operationalisable for practical purposes (Doyle & Perez-Alaniz, 2017). This operationalisation occurs by integrating results from high-level policies, scholarly work, sector-specific policies, and practice as a guideline and applying them to specific cases or problems. Scholars suggest paying particular attention to processes through which social value practice occurs at the operation level (Vallance et al., 2011), as it provides an umbrella to explore different facets of the concept, such as social infrastructure, social capital, and social justice and equity (Cuthill, 2010). Also, the thematic approach serves as a foundation for analysis.

Scholars assert that measuring the impact of social value at the enterprise level requires a balance between quantitative and qualitative indicators as a basis for the analysis (Staniškienė & Stankevičiūtė, 2018). Currently, many scholars apply thematic indicators as a foundation to capture both quantitative and qualitative aspects of their proposed analytical frameworks. For instance, Cuthill (2010) developed a conceptual framework for empirical testing that included four themes: social justice and equity, social capital, social infrastructure, and engaged governance. Thus, in addition to the qualitative analysis, themes can be used as a foundation for developing analytical frameworks that are also considered a necessity in the field (Griessler & Littig, 2005). Building on the tenant of Corporate Social Responsibility (CSR), we identified three themes of social value, including *stakeholder engagement, inclusion* and *ethics*, with their respective indicators for this study.

2.4.1. Stakeholder engagement theme

Stakeholders are groups or individuals that can influence or be influenced by the enterprise's performance (Freeman, 2010). It is argued that conventional social value objectives can be achieved more effectively through managing stakeholder relationships (Donaldson & Preston, 1995). Some scholars define the concept of social value with respect to enterprise stakeholders (Khoury, Rostami, & Turnbull, 1999); (Jackson & Hawker, 2001); (Lea, 2002); (Van Marrewijk, 2003); (Hopkins, 2003). For instance, sustainable social value is defined as organisational trust, legitimacy, and transparency in social communication with respect to internal and external stakeholders (Galuppo, Gorli, Scaratti, & Kaneklin, 2014). The general argument of stakeholder theory is to deliver value to as many stakeholders as feasible while maintaining a balanced relationship between all stakeholders (Verdeyen, Put, & van Buggenhout, 2004). Maintaining such balance represents a challenge in the current business practice in which stakeholders’ expectations exceed the sheer economic objectives (Pappas et al., 2018) to cover social and environmental concerns and demands for enabling interaction with stakeholders (Boons & Lüdeke-Freund, 2013). Achieving such balance entails attending to different aspects of stakeholders' expectations, such as power, legitimacy and urgency (Mitchell et al., 1997). Adopting this perspective implies that the viewpoint of different stakeholder groups needs to be included in the decision-making process for a socially sustainable value delivery practice (Nambisan, 2017); (Magis, 2010); (Pappas et al., 2018). Consequently, stakeholder management requires closer engagement and collaboration for a strategic balance between stakeholders (Manda & Ben Dhaou, 2019). Over the past decades, the literature classified the drivers of stakeholder engagement (Frynas & Yamahaki, 2016). These drivers have a diversified nature, including humanitarian, environmental, external pressures and regulations to profitability concerns, and are associated with increased enterprise sensitivity towards social issues and stakeholders' concerns (Epstein, 2018). As a result of such sensitivity, it is argued that stakeholder engagement could promote social values such as building trust and commitment and fostering collaboration amongst stakeholders and corporations (Gao & Zhang, 2006). Also, the role of digital technologies in such a transformation in societies and in delivering social and environmental value is well articulated (Linkov et al., 2018).

At the conceptual level, digital technologies hold the potential of both delivering economic value and serving to fulfil the social expectations of stakeholders (Jovanović et al., 2018). Hence, we argue that stakeholder engagement is one facet of social value that digital technologies can influence. Table 2 presents how the theme of engaging with stakeholders is measured in the literature.

Hypothesis 4: The concept of digitalisation is associated with enhanced communication of stakeholder engagement.

Table 2. Engaging with stakeholders

Indicators used to develop keywords for capturing engaging with stakeholders related communication on social media
• A sense of community ownership (McKenzie, 2004) • Community participation (Doyle & Perez-Alaniz, 2017) • Community stability (contribution to) (Doyle & Perez-Alaniz, 2017) • Enabling the stakeholders to control the spaces that belong to them (Staniškienė & Stankevičiūtė, 2018) • Engaging neighbours in building design and construction process planning (Staniškienė & Stankevičiūtė, 2018) • Ensuring equity and recognising the different statuses of stakeholders (Staniškienė & Stankevičiūtė, 2018) • Freedom of Association and Collective Bargaining (contribution to) (Staniškienė & Stankevičiūtė, 2018) • Grievance Mechanisms for Impacts on Society (Staniškienė & Stankevičiūtė, 2018) • Information provision (Staniškienė & Stankevičiūtė, 2018) • Interactions in the community/social networks (Doyle & Perez-Alaniz, 2017) • Investments in community projects ($) (Epstein & Roy, 2001) • Participating and holding local social events (Staniškienė & Stankevičiūtė, 2018) • Politics: Enjoy meeting others with differences (Magee et al., 2012) (Mani et al., 2016) • Provision places that enable social interaction and group formation (Staniškienė & Stankevičiūtė, 2018) • Satisfying the territoriality needs of the stakeholders, such as the assumed rights and privilege over space (Staniškienė & Stankevičiūtė, 2018) • Stakeholder engagement (Govindan et al., 2013) • Stakeholder Influence (taking into account) (Staniškienė & Stankevičiūtė, 2018) • Stakeholder participation (Staniškienė & Stankevičiūtė, 2018) • Strength of networks, participation, identification, and tolerance (Staniškienė & Stankevičiūtė, 2018) • Supplier Assessment for Impacts on society (Staniškienė & Stankevičiūtė, 2018)

- Supporting community projects (Govindan et al., 2013)

2.4.2. Inclusion theme

Inclusion is regarded as one of the building blocks of society's institutions (Doyle & Perez-Alaniz, 2017). This concept is associated with concepts such as justice and accountability (ibid.), and it seeks to maximise human competencies and attain harmony in the context of the society (Gidley, Hampson, Wheeler, & Bereded-Samuel, 2010); (Dugarova, 2015) (Doyle & Perez-Alaniz, 2017). Inclusion pertains to a wide range of activities, such as gender equality, labour, and equity of public resource access (Khalid Anser et al., 2021). Inclusion is often discussed at the individual level. Examples include the inclusion of women (R. Schillo & Robinson, 2017); (Chau & Quire, 2018); (Krieger-Boden & Sorgner, 2018), the inclusion of people with special needs, and the inclusion in employment (Miethlich & Oldenburg, 2019); (Thomsen, 2020). The discussion of the topic includes diversified domains such as gender and sexual orientation, socioeconomic status, culture and language, ethnicity such as indigenous inclusion, health, including physical and mental disabilities, and immigration (Gidley et al., 2010); (Haluza-DeLay & Fernhout, 2011). Also, the concept of social inclusion is considered the counter-argument to social exclusion (Short, 2021). Therefore, inclusion is often referred to as ending evident and subtle exclusion, for example, based on age, disability and location (Dugarova, 2015).

Current research shows that promoting social inclusion can bring various advantages and enhance economic performance, especially in the service sector (Miethlich & Oldenburg, 2019). Yet, despite such advantages and support at the macro level of decision making (Arond, Rodríguez, Arza, Herrera, & Sánchez, 2011), the literature highlights several obstacles to achieving inclusion at the enterprise level. For example, inclusion is argued to be time-intensive, triggers possible tension between partners, includes different perceptions, and lacks a holistic approach to attaining state of the art (Gidley et al., 2010). At the same time, the inclusion process tends to be determined based on locally developed values (Dugarova, 2015). Hence, the topic might be subjective when implemented and measured at the enterprise level, with limited evidence on alleviating the situation (Haluza-DeLay & Fernhout, 2011). However, inclusion considerations at the enterprise level is regarded to lead progressive institutionalisation within society (Archie B. Carroll, 2015). Furthermore, empirical analyses have shown indicators can be successfully developed to measure social inclusion and distribution of equity in local communities (Haluza-DeLay & Fernhout, 2011); (Fritz & Koch, 2014); (Lupala, 2014). In addition, the literature highlights the role of emerging digital innovations like Virtual Reality (VR) in facilitating the process of inclusion (Byers, Hayday, Mason, Lunga, & Headley, 2021); (von Schönfeld & Ferreira, 2021). Thus, the contemporary approach calls for perceiving inclusion as an opportunity to develop innovative solutions rather than an obstacle to overcome (Rossi, 2021). Table 3 presents how the theme of social inclusion is measured in the literature. We focus on the inclusion of individuals at the enterprise level.

Hypothesis 5: The concept of digitalisation is associated with enhanced communication of social inclusion.

Table 3. Social inclusion

Indictors used to develop keywords for capturing social inclusion related communication on social media
• Achieve gender equality and empower all women and girls (Doyle & Perez-Alaniz, 2017) • Audits supplier locations and ensures non-employment of child and bonded labour (Mani et al., 2016) • Ensure workplace diversity at customer locations (Mani et al., 2016) • Ensures diversity at supplier locations (Mani et al., 2016) • Ensures gender non-discrimination policy in our suppliers (Mani et al., 2016) • Ensures strict adherence to gender non-discrimination policy in customer locations (Mani et al., 2016) • Gender non-discrimination (suppliers, manufacturers and customers) (Mani et al., 2016) • Has human rights policy for our manufacturing facilities (Mani et al., 2016) • Human rights (Customer) (Mani et al., 2016) • Human rights (Supplier and Manufacturer) (Mani et al., 2016) • Increase gender diversity (% of workforce) (Epstein & Roy, 2001) • Indigenous rights (Staniškienė & Stankevičiūtė, 2018) • Non-discrimination (Staniškienė & Stankevičiūtė, 2018) • Organisation ensures equal opportunities for males and females to further their careers (Staniškienė & Stankevičiūtė, 2018) • Supplier Human rights Assessment (Staniškienė & Stankevičiūtė, 2018) • Support programs for minority-owned businesses (% of volume of business) (Epstein & Roy, 2001) • Workplace diversity (Manufacturer) (Mani et al., 2016) • Workplace diversity (Supplier's) (Mani et al., 2016)

2.4.3. Ethics theme

Ethics with other notions such as morals, human rights, and philanthropy are considered different dimensions of social value (Carter & Jennings, 2002; Mani et al., 2016). At the enterprise level, the concept of ethics implies a voluntary commitment to public welfare and observing the interest of vulnerable groups in society and participating in charitable activities (Maon, Lindgreen, & Swaen, 2010); (Tsai & Xue, 2013); (Agudo-Valiente, Garcés-Ayerbe, & Salvador-Figueras, 2017). Such observation includes rectifying the harm when discovered (Campbell, 2007). Ethical considerations require taking discretionary actions beyond legal enforcement to comply with the unwritten social standards, norms, and values (Castelo Branco & Lima Rodriques, 2007); (Maon et al., 2010); (Mazutis, 2014). Ethical consideration by the enterprise can lead to a positive societal impact. It is argued that due to the business capability in resource allocation and problem-solving, businesses have a greater impact on social welfare than any other social institution or philanthropic organisation (M. E. Porter & Kramer, 2006). Thus, ethical obligations at the enterprise level can improve value delivery to society (Epstein, 2018). The motive of attending to ethical demands is explained through instrumental, legitimacy, and normative perspectives. The instrumental approach uses conventional statistical analysis to assess how attending to ethical issues is beneficial for finical performance (Donaldson & Preston, 1995); (Epstein & Roy, 2001). This commitment is often discussed from a managerial perspective and motivation of managers to attend to non-economic values (Wood, 1991); (Swanson, 1995); (Maon et al., 2010); (Agudo-Valiente et al., 2017). The legitimacy perspective discusses obtaining the required legitimacy from society and emphasises building acceptable norms of behaviour with societal stakeholders and what motivates managers to attend to societal values (Basu & Palazzo, 2008); (Agudo-Valiente et al., 2017). The normative perspective is a moral commitment motivated by internal norms and ethics (Basu & Palazzo, 2008). Due to increasing demands by individuals and society, the approach to ethics is shifting from an instrumental to a moral motives perspective (Aguilera et al., 2007). The role of socially conscious individuals empowered by digital technologies in promoting demand for ethical and philanthropic behaviour is acknowledged in such a perspective transformation (H. Wang, Choi, & Li, 2008). Today, digital technologies such as social media have provided conscious individuals with a means to express their opinions and expectations on ethical values (R. Wang & Huang, 2018); (Ahmad et al., 2021). These technologies enable individuals to become digital activists engaged in community improvement (Chamakiotis, Petrakaki, & Panteli, 2021). Thus, despite ethical concerns around the behaviour of big digital companies, digital platforms are inspiring and amplifying ethical and philanthropic demands (Manning, Baker, & Stokes, 2020). Reciprocally, organisations use the same digitally-enabled platform to communicate ethical values and attract stakeholders (Liu, Jiang, & Zhao, 2019). Additionally, the current pandemic crisis has enhanced the call for ethical and philanthropic consideration in the digital world (Srinivasan & Eden, 2021). Table 4 presents how the theme of ethics is measured in the literature.

Hypothesis 6: The concept of digitalisation is associated with enhanced communication of ethics.

Table 4. Ethics

Indicators used to develop keywords for capturing ethics-related communication on social media
• Access to services, facilities and opportunities (facilitating) (Staniškienė & Stankevičiūtė, 2018) • Audits the customer place for strict compliance with ethical code of conduct (Mani et al., 2016) • Child Labour (exclusion of) (Staniškienė & Stankevičiūtė, 2018) • Conducts health-related camps for the society surrounding our manufacturing facilities (Mani et al., 2016) • Encourage suppliers in philanthropic activities (Mani et al., 2016) • Ensure non-employment of sweatshop labour in supplier locations (Mani et al., 2016) • Ensures our manufacturing unit donates to NGOs for societal development (Mani et al., 2016) • Ensures our manufacturing unit donates to religious organizations (Mani et al., 2016) • Ensures our manufacturing unit volunteers at local charities (Mani et al., 2016) • Established an ethical compliance team, department or division in our manufacturing facilities (Mani et al., 2016) • Ethical issues (Manufacturers and Customers) (attending to) (Mani et al., 2016) • Ethical issues (Suppliers) (attending to) (Mani et al., 2016) • Forced or Compulsory Labour (Staniškienė & Stankevičiūtė, 2018) • Grants and donations (Govindan et al., 2013) • Has established a set of transparent, comprehensive and stringent ethical codes of conduct in our manufacturing units (Mani et al., 2016) • Philanthropic activities (Customers) (Mani et al., 2016) • Philanthropic activities (Supplier) (Mani et al., 2016) • Philanthropy (Manufacturers) (Mani et al., 2016)

3. Methods

This study aims to examine whether the increased communication of digitisation and digitalisation is associated with the increased communication of social values. The analysis included examining the relationship between digital and social sets of variables through performing Ordinary Least Squares regression (OLS) models to measure the impact of digital communication in 2019 tweets on social communication in 2020 tweets. The analyses are conducted based on measuring the weight of the tweeted keywords. The keywords were designed based on digital indicators from Table 1 and social indicators from Tables 2, 3, and 4. We examined whether higher digital communication can improve social value communication on Twitter through regression analysis. The tweets sample is collected from organisations in the Canadian Agri-food sector.

3.1. Data and Sample

The empirical analyses are based on a data set of 781 organizations in the Canadian Agri-food sector. Sample selection for this study followed two approaches. First, a systematic collection of the organisation was conducted in Capital IQ. In this approach, companies were collected from the entire agriculture Agri-food sector across Canada. The companies were selected based on the primary and supportive activities of the Agri-food value chain. The spectrum included enterprises operating in the industry's supply chain, including agriculture inputs, production, harvest, post-harvest handling and processing. Additionally, enterprises provide support services such as consultancy, equipment and logistics. Second, an unsystematic collection of the organisation is conducted based on lists of membership received from Canadian associations. In addition to economic stakeholders, the association lists included non-economic stakeholders such as different associations, NGOs, government divisions and other social and societal stakeholders. The next step included selecting organisations whose Tweet accounts could be retrieved and validated through their website. All tweets from January 1, 2019, to December 31, 2020, were downloaded for the selected companies, resulting in a data set of 532,673 tweets. As inclusion criteria, only accounts with at least 12 tweets (an average of 1 tweet per month) in both years 2019 and 2020 and accounts with a maximum of 1200 tweets per year (an average of 100 tweets per month) were included in the final analysis.

The sample is collected from the Canadian Agri-food ecosystem. The agriculture and agri-food industries around the globe are intensively undergoing digital transformation with the increasing demand for attending to the social issue (Carolan, 2017); (Wolfert et al., 2017); (Eastwood, Klerkx, Ayre, & Rue, 2019); (Klerkx, Jakku, & Labarthe, 2019). As a leading economy, the application of sophisticated digital technologies is promoted at Canada's highest level of decision and policy making (Government of Canada, 2021). As a result, digital agriculture technologies are rapidly developing in the Canadian agri-food ecosystem with the involvement of various stakeholder groups (Ebrahimi, Schillo, & Bronson, 2021). Such a diversity accommodates examining the concept in the context of the ecosystem rather than a narrowly defined sample. A summary of the included organisation is presented in Table 5.

Table 5. Distribution of included Twitter accounts across the Canadian Agri-food ecosystem

Category	*Observation*
Association and NGOs	58
Dining & Pubs (including Recreation)	87
Education	13
Equipment	52
Government & Institution	7
Health	38
Infrastructure	6
Logistics	7
Market Services	109
Production & Process (including Brewage)	315
Science	8
Wholesalers & Retail	80
Total	**781**

3.2. Measures

Measure-building involved the calculation of the weight of six indicators (digitisation, digitalisation, stakeholder engagement, social inclusion, ethics, and an overall social value) for each account. The measure of overall social value aggregated all the keywords of social facets (stakeholder engagement, social inclusion, and ethics). The weights are calculated according to the *Term Frequency and Inverse Documentation Frequency* (TF.IDF) technique in a Python algorithm (for more information on TF.IDF, look at Aizawa (2003), for an example on application look at Gaydhani, Doma, Kendre, and Bhagwat (2018)). TF.IDF measures the uniqueness of a given keyword (Adamson et al., 2013). The term Invers in the IDF serves as a mechanism to give higher weights to less frequent terms. Since this study aims to give higher weight to more frequent keywords as a proxy of increased communication, the inversed ratio is reversed (1/ IDF). For each Twitter account, this algorithm takes into account the sum of keyword occurrence for each theme, the sum of tweets that contain at least one keyword of each theme, and the total number of tweets in a given year.

Analysis of the variables indicated skewness in the distribution of focal and control variables. Hence, they are normalised by applying the logarithm of variables. Further, the analysis of the logarithmic weights of the focal variables showed a mean below one (Tables 6). Thus, a Tobit test is conducted to ensure robustness (see Appendix 1). Table 6 presents the Variance Inflation Factor (VIF) test for the predictors and control variables.

Table 6. VIF test

Variable	VIF	Tolerance (1/VIF)
Digitisation	1.215	0.823
Digitalisation	1.531	0.653
COVID 19	1.155	0.866
Likes Average	1.105	0.905
Following	1.783	0.561
Followers	2.145	0.466
Media	2.036	0.491
Number of Tweets 2019	1.851	0.540

3.2.1. Independent and control variables

The analysis included two focal digital variables of *digitisation* and *digitalisation*. These two variables served as the main predictors of social variables. The models are complemented by including six control variables: *likes average*, number of *following* accounts, number of *followers* accounts, number of *media* content, and *number of tweets in 2019*. To control for the impact of the crisis, we created a control variable of *COVID 19* which measured pandemic related communication.

3.2.2. Dependent variables

The analyses included four social variables of *stakeholder engagement, social inclusion*, and *ethics* as different themes of social value, and the variable of *social value* as the main social variable that combined all three social variables (*stakeholder engagement, social inclusion*, and *ethics*). These variables are applied as dependent variables in the models.

3.3. Results

To test the first hypothesis, we performed an OLS regression analysis by applying the main social variable, social value (this variable included all indicators of the three social facets of the study), as the dependent variable, and digitisation and digitisation as the predictors (see Table 8). The model produced an adjusted R^2 of 34.7% and demonstrated direct and positive relationships between both digitisation and digitalisation and the dependent variable of social value. In this model, the digital coefficients remained both positive and statistically significant: digitisation (β=0.091; p=0.005) and digitalisation (β=0.168; p< .001). These results occur in spite of strong and statistically significant coefficients of the control variables: COVID 19 (β=0.238; p< .001), number of tweets in 2019 (β=0.166; p< < .001), and followers (β=0.092; p< 0.030). Additionally, the likes average and the number of following accounts were not statistically significant in predicting the communication of social value.

Therefore, the analysis provided evidence supporting the hypothesis that the communication of digital technologies positively contributes to the communication of social value issues. Moreover, this analysis also generated evidence supporting the second hypothesis that the communication of digitalisation can lead to improved communication of social value.

However, the null hypothesis cannot be rejected within the third hypothesis. The model connoted a statistically significant relation between digitisation and social value communication. According to the literature, this finding is particularly interesting as digitisation is related to internal efficacies. The literature does not clearly explain how an internal issue like efficiency can contribute to the communication on externally driven topics such as social value.

Table 7. Pearson's Correlations (Pearson's r)

Variable	STK	INC	ETH	DG1	DG2	COV	LIK	FLG	FLR	MED	N19
Stakeholder Engagement	1.00										
Social Inclusion	0.579***										
Ethics	0.438***	0.542***									
Digitisation	0.219***	0.318***	0.223***								
Digitalisation	0.360***	0.395***	0.344***	0.380***							
COVID 19	0.369***	0.426***	0.294***	0.189***	0.307***						
Likes Average	-0.100**	-0.067	-0.127***	-0.003	-0.008	-0.067					
Following	0.194***	0.155***	0.186***	0.101**	0.124***	0.078**	-0.268***				
Followers	0.282***	0.285***	0.266***	0.129***	0.223***	0.131***	-0.229***	0.635***			
Media	0.332***	0.321***	0.320***	0.182***	0.341***	0.223***	-0.088*	0.479***	0.61***		
Number of tweets 2019	0.377***	0.379***	0.400***	0.342***	0.527***	0.313***	-0.107**	0.259***	0.38***	0.543***	1.00
Mean	0.402	0.253	0.517	0.362	0.581	0.297	1.466	6.214	7.260	5.915	4.822
Std. Deviation	0.590	0.511	0.705	0.670	0.729	0.501	1.003	1.438	1.513	1.430	1.208

* p < .05, ** p < .01, *** p < .001

Table 8. Regression Results, Digital Variables

	Base Model	Digital Variables
(Intercept)	***	***
Digitisation		0.091**
Digitalisation		0.168***
COVID 19	0.273***	0.238***
Likes Average	-0.046	-0.059
Following	0.004	0.007
Followers	0.097*	0.092*
Media	0.123**	0.113**
Number of tweets in 2019	0.270***	0.166***
F Statistic	61.082	52.809
R^2	0.321	0.354
Adjusted R^2	0.316	0.347
RMSE	0.837	0.818

* p < .05, ** p < .01, *** p < .001

In order to further analyse the findings and obtain more granularity, we separated the main dependent variable (social value) into its three themes. Then, the same regression model is repeated for each of the three dependent variables of *stakeholder engagement*, *social inclusion* and *ethics*. The summary of the analyses is presented in Table 9. The findings of this step served to test hypotheses 4, 5, and 6. Also, the finding assisted in explaining the phenomenon of the significance of digitisation on the communication of social value observed when testing the third hypothesis.

Table 9.

Regression Results - stakeholder engagement, social inclusion, ethics

	Dependent variables					
	Model H_0			**Model H_1**		
	Stakeholders	**Inclusion**	**Ethics**	**Stakeholders**	**Inclusion**	**Ethics**
Digitisation				0.046	0.151***	0.057
Digitalisation				0.156***	0.161***	0.136***
COVID 19	0.270***	0.335***	0.178***	0.241***	0.296***	0.152***
Likes Average	-0.029	0.004	-0.063	-0.039	-0.011	-0.072*
Following	0.001	-0.057	-0.004	0.006	-0.056	-7.152e-4
Followers	0.105*	0.162***	0.078	0.101*	0.158***	0.074
Media	0.098*	0.074	0.088	0.088*	0.066	0.079
Number of tweets 2019	0.196***	0.188***	0.261***	0.111**	0.068	0.182***
F Statistic	40.378***	48.832***	34.815***	33.881***	45.743***	28.997***
R^2	0.238	0.275	0.213	0.260	0.322	0.231
Adjusted R^2	0.232	0.269	0.206	0.252	0.315	0.223
RMSE	0.517	0.437	0.628	0.510	0.423	0.621

* p < .05, ** p < .01, *** p < .001

The analysis of the three dependent variables demonstrates a consistent pattern of digitalisation as a positive and significant predictor of all three dependent variables of social facets. Thus, evidence is generated in supporting hypotheses 4, 5 and 6. However, the coefficients, R^{2}'s and control variables vary in each model. *Social inclusion* shows the highest adjusted R^2 of 31.5% and the lowest Root Mean Square Error (RMSE) of 0.423. *Stakeholder engagement* shows an adjusted R^2 of 25.2% and RMSE of 0.510. Furthermore, *Ethics* shows the least adjusted R^2 of 22.3% and the highest RMSE among the three models (0.621).

Digitalisation is significant in the *stakeholder engagement* model (β=0.156 and a significant p-value of 0.001). In contrast, digitisation is not statistically significant. Among the control variables, COVID 19 (β=0.241; $p < .001$) has the highest significant coefficient flowed by the number of tweets in 2019 (β=0.111; $p < 0.008$), the number of followers (β=0.101; $p < 0.027$), and the number of applied media (β=0.088; $p < 0.047$). On the other hand, the likes average and the number of following accounts are not statistically significant in predicting the communication of stakeholder engagement keywords.

Digitalisation is significant in the *social inclusion* model (β=0.161 and a significant p-value of $< .001$). Also, compared to the *stakeholder engagement* model, β demonstrates an improvement. Additionally, digitisation is statistically significant in this model (β=0.151; $p < .001$). Among the control variables, two variables of COVID 19 (β=0.296; $p < .001$), with the highest coefficient in the model, and the number of followers (β=0.158; $p < .001$), are also statistically significant. On the other hand, the likes average, the number of following accounts, the number of applied media, and the number of tweets in 2019 are not statistically significant in predicting the communication of stakeholder inclusion keywords.

In the *Ethics* model, digitalisation is significant (β=0.136 and a significant p-value of $< .001$). However, compared to the other two models, this is the lowest β coefficient of digitalisation. Similar to the *stakeholder engagement* model, digitisation is not statistically significant. Among the control variables, two variables of the number of tweets in 2019, with the highest coefficient (β=0.182; $p < .001$), and COVID 19 (β=00.152; $p < .001$) are statistically significant and positively contribute to the model. On the other hand, the likes average (β= -0.072; $p < 0.030$) has a statistically significant negative contribution. The number of following accounts, the number of follower accounts, and the number of applied media are not statistically significant in predicting the communication of ethical-related keywords.

Reviewing the summary of the regression analyses reveals that *social inclusion* is the only model that shows a statistically significant contribution to digitisation. Thus, *social inclusion* can potentially explain the observed phenomenon of statistically significant digitisation coefficients in the general social value model.

4. Discussion

The discussion is conducted based on the two main findings of the analysis. First, we explain the observation of the positive impact of the communication of digitalisation on the communication of the overall social value based on the literature. This pattern is a constant observation in the aggregated social value model and in the three models of social facets. Second, we explain the phenomenon of the positive impact of digitisation on the communication of social inclusion.

4.1. Impact of digitalisation on social value perception

Digitalisation implies the application of sophisticated digital technologies in collecting information and interacting with the external environment. As discussed in chapter two, this stage is associated with developing user-centric capabilities and increased interaction with the external environment (Gray et al., 2013); (Matt et al., 2015); (Stock & Seliger, 2016); (Legner et al., 2017). Digital technologies such as big data analytics can collect information from multiple stakeholders (W. Li et al., 2012); (Pappas et al., 2018). Also, these technologies provide surveillance capabilities to monitor the external environment (W. Li et al., 2012); (Doyle & Perez-Alaniz, 2017); (Linkov et al., 2018) and enable the enterprise to set the required trade-offs over time (Epstein, 2018). Additionally, they have the capability to build communicative platforms with other stakeholders (W. Li et al., 2012); (Legner et al., 2017); (Weber et al., 2017); (Lavassani, Forsström, Jennehag, & Zhang, 2018); (Linkov et al., 2018). Thus, these technologies enabled the enterprise to gain information and feedback from multiple stakeholders at a lower cost that previously was not easily acquirable (Acs, Stam, Audretsch, & O'Connor, 2017).

As a result, scholars argue that digitalisation has changed two assumptions of stable enterprise boundaries and the enterprise as the sole source of innovation (Gray et al., 2013); (Woerner & Wixom, 2015); (Matt et al., 2015); (Woerner & Wixom, 2015); (Legner et al., 2017); (Nambisan, 2017). These two assumptions can be applied to explain the positive impact of digitalisation on the communication of social value. First, digitalisation dissolves the enterprise boundaries and made a shift from a disconnected and stable internal environment to an increasingly fluid boundaries where the impact can be exchanged with the external environment. Second, digitalisation has led to a change in the perception that the enterprise is the main actor of innovation. As a result of facilitated interaction with the external environment, customers and other stakeholders are now considered sources of innovation and value creation. Thus, digitalisation paved the way for engaging with broader, diversified and dynamic stakeholders with varied objectives, motives, and capabilities (Nambisan, 2017). As the enterprise boundaries begin to dissolve (Matt et al., 2015);(Nambisan, 2017), the perception of the source of value also finds external impactions (Woerner & Wixom, 2015); (Nambisan, 2017). Making decisions in such a transforming situation demands collecting data from the external environment, monitoring competitors and acquiring feedback from customers (W. Li et al., 2012).

On the other hand, the expansion of digital technologies and platforms has led to the digital empowerment of individuals and society (Kummamuru, Narayana, & Chopra, 2012); (Govindan et al., 2013), (R. Wang & Huang, 2018); (Ahmad et al., 2021). Such empowerment justifies approaching the external actors and stakeholders as co-creators of private value, sources of knowledge and external factors of production (Gray et al., 2013). Thus, the enterprise is encouraged to design strategies to assess external opportunities and engage in communications on various stakeholders issues, including, but not limited to, customer's expectations as a source of value (Gray et al., 2013); (Stock & Seliger, 2016). Consequently, this approach leads the enterprise to observe the value and demands of external individuals, other organisations and various social and non-social stakeholders (W. Li et al., 2012). Thus, we conclude digitalisation can be associated with improved social value observation within the enterprise. Therefore, those organisations that showed higher communication of digitalisation may have improved social value consideration and are likely to indicate such value on their social media. Thus, we conclude that attending to the external environment as a source of value increased the enterprise's capability to develop positive communication of the type of value appreciated in its external environment, including the value with respect to stakeholder engagement, social inclusion, and ethics.

4.2. Impact of digitisation on social inclusion perception

The analysis generated an unexpected result where increased communication of digitisation, which is regarded as an internal subject of efficiency, has a significant positive impact on the communication of social inclusion. Considering that the analysis of social inclusion was focused on the individual level, for example, the inclusion of women, it can provide an insight into the phenomenon. The current studies show that digital skills and training to use digital tools can improve women's inclusion and enhance gender equality in the business domain (Martinez Dy & Jayawarna, 2020); (Gutiérrez-Esteban, de Paula Rodríguez-Miranda, Cubo-Delgado, & Hernández-Rincón, 2021). Scholars argue implementing digital technologies in the workplace can provide the required flexibility for women's inclusion (Churchill & Craig, 2019). Such flexibility occurs through the digitisation of physical jobs, which can likely reduce gender bias (Roos et al., 2021). From this perspective, operating digital technologies require intellectual capabilities that, in return, can reduce the workplace's traditional physiological, racial, and other discriminative biases. Such a perspective is supported by statical evidence that gender is not significant in the digital skills and capabilities needed to operate digital technologies (Vasilescu, Serban, Dimian, Aceleanu, & Picatoste, 2020). Yet, some studies suggest that women are more effective in incorporating digital technologies into their work practice (Wiseman, Al-bakr, Davidson, & Bruce, 2018). As a result, scholars argue that women's jobs, compared to those of men, are less likely to be risked by digitisation (Adebiyi, 2019); (Kohlrausch & Weber, 2021). Therefore, digitisation can provide tools to downturn the challenges of gender inclusion (Larsson & Viitaoja, 2019). For example, automation is argued to be interlinked to gender equality (Faith, 2017). Thus, we conclude digitisation can be associated with improved social inclusion within the enterprise. Therefore, those organisations that showed higher communication of digitisation may have improved social inclusion in their workplace and are likely to indicate such value on their social media. However, the relation between digitisation and enhanced women's inclusion in the workplace does not imply improved women’s inclusion at all enterprise levels. Rather, it may imply a subtle inequality. Most digitised jobs are concerned with automation and are not considered high-level decision-making positions. This finding confirms the results of similar studies that women are underrepresented at the top level of decision-making in digital enterprises (Faith, 2017); (R. S. Schillo & Ebrahimi, 2021). However, biased practice seems to be a result of established policies regarding patterns of production rather than a direct impact of digital technologies (Kohlrausch & Weber, 2021).

5. Conclusion

This study examines whether increased communication of two levels of digital technologies, namely digitisation and digitalisation, could contribute to the communication of social value in social media. Although there are serious and legitimate concerns that digital technologies have not contributed to levelling the playground for improved social practice, including social inclusion, the findings of this study suggest at the enterprise level, communication of digital technologies could lead to increased communication of some social dimensions. The study is conducted on a sample of organisations from the Agri-food ecosystem in Canada. The statistics models showed that organisations with higher communication of digital technologies, particularly digitalisation-related keywords, demonstrated a higher level of social value communication on the Twitter platform. Social communication included stakeholder engagement, social inclusion, ethics, and the overall social value. Digitalisation technologies, compared with digitisation, are more sophisticated and can be used by the enterprise to interact with the external environment. The communication of these technologies served as a predictor of all social value themes that are measured in this study. By deploying these technologies, the enterprise can acquire insight into the value appreciated by its surrounding environment and stakeholders. Hence, it becomes more sensitive to observing the expectations of its stakeholders when communicating on social media platforms.

Further, our analysis showed that although digitisation-related communication does not contribute to stakeholder engagement and ethics communication, it can positively contribute to the communication of social inclusion. Digitisation technologies are concerned with automation and manual processes. The phenomenon can be explained as operating digital technologies, and digital literacy can render the inclusion bias based on gender and ethnic background and similar biases. Thus, organisations that tweeted about digitisation showed higher sensitivity and communication of social inclusion.

However, our findings do not suggest that organisations with higher communication of the detected social themes in this study have improved social value delivery in practice. Examining the assumption of whether improved communication of social value on social media platforms can be translated as improved social value delivery in practice requires further studies and different data collection methods. Similarly, our findings do not suggest that communication of a certain level of technology (for example, digitalisation) is associated with the implementation of the related technologies at the enterprise level.

However, the findings of this study have two implications from managerial practice and policy perspectives. First, developing strategies for implementing and utilising digitalisation technologies can provide an affordable method for identifying opportunities and collecting data on diversified stakeholders' demands, including the demand for social value. Second, from a policy perspective, promoting digitisation and digitalisation initiatives can positively impact the perception of social value in the ecosystem. In addition to improved efficiency and competitiveness when applied in practice, our study showed communication of these technologies could positively impact the communication of social value at the enterprise level. When such initiatives are promoted within an ecosystem, digital technologies can contribute to improved social value delivery at the aggregated level as well as increase the communication of social value in the ecosystem. Therefore, we call for further investigation of the impact of digitalisation technologies on social value at the ecosystem level. Also, we call for investigating the impact of digitisation on social inclusion at the enterprise level, especially the impact of automation on gender equality. Therefore, we call for further investigation of the impact of digital transformation on social value delivery to society. Particularly, examining whether increased social value communication can be translated as improved social value delivery in practice is a great opportunity for future research.

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1.

Appendix 1

Tobit regression

	(1) lw_soc	(2) lw_stk	(3) lw_inc	(4) lw_mor
lw_dg1	.1639***	.0674	.2292***	.0747
	(.0601)	(.0471)	(.0571)	(.0551)
lw_dg2	.2623***	.1787***	.1727***	.1572***
	(.0621)	(.0487)	(.0603)	(.056)
lw_cov	.5475***	.4021***	.5507***	.2973***
	(.0781)	(.0604)	(.0728)	(.0696)
l_likes_ave	-.1201***	-.1024***	-.0956*	-.114***
	(.0418)	(.0356)	(.0492)	(.0387)
l_following	.0149	.0021	-.0293	.0022
	(.0351)	(.0282)	(.0377)	(.0323)
l_followers	.0582	.0606**	.0844**	.0404
	(.0364)	(.0294)	(.0387)	(.0331)
l_media	.1328***	.1037***	.1829***	.0825**
	(.0391)	(.0332)	(.049)	(.0362)
l_n_19	.1829***	.1111***	.134***	.2081***
	(.0423)	(.035)	(.0473)	(.0393)
_cons	-1.5934***	-1.614***	-2.8394***	-1.6184***
	(.255)	(.2149)	(.3119)	(.2376)
/var(e.lw_soc)	1.0014***			
	(.061)			
/var(e.lw_stk)		.5702***		
		(.0412)		
/var(e.lw_inc)			.726***	
			(.07)	
/var(e.lw_mor)				.7665***
				(.0529)
Observations	781	781	781	781
Pseudo R^2	.1463	.163	.225	.1267

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

Digital Agriculture, Smart Farming and Ag 4.0: Clarifying the social science conceptual terrain

As the agriculture sector is in the midst of a digital revolution, the emerging scholarly work focusing on this topic is at a stage of divergent conceptual treatment of the phenomena associated with this transition. Given that digital technologies and innovation take place in a complex ecosystem of interrelated social and technical elements, thus the applied concepts ought to account for this complexity. We map different conceptualisations of digital technologies applied to agriculture and apply the definition of digitisation and digitalisation to assess the inclusion scope of the concepts used to refer to current technology-led social shifts in agriculture. We argue that concepts such as precision agriculture refer to technical aspects, while concepts like digital and smart agriculture go beyond these to include socio-economic and socio-ethical implications. We conclude that the term "digital agriculture" thus has ecosystem implications and is capable of capturing wider stakeholder groups in analysis, which is necessary for ethical innovation.

Keywords: digital agriculture; innovation; stakeholders; ecosystem; inclusion

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Current digital-led shifts in agriculture

The agricultural sector has proven to be a fertile field for technological breakthroughs – from the industrial revolution, to the green revolution, the biotechnology revolution, and more recently, what has been referred to as the "digital revolution" (Carolan, 2017). The digital revolution is taking place via information and communication technologies in farm management (Wolfert, Ge, Verdouw, & Bogaardt, 2017), with significant effects on efficiency and productivity. For example, three-quarters of key commodity crops like corn are being produced under the influence of digital agricultural technologies, and their influence is expected to grow (Carolan, 2017). The revolution involves autonomous machines applied particularly in labour-intensive industries such as dairy (Eastwood, Klerkx, Ayre, & Rue, 2019) and the application of advanced digital techniques such as automated transferring, processing, and the analysis of big data (Korotchenya, 2019). These sophisticated data computing techniques are used to develop data-driven insights on when to seed, spray or harvest. As a result, current farm decisions are increasingly supported by digital technologies such as track guiding systems, GPS mapping, soil sampling sensors, site-specific fertilisation and so on (Busse et al., 2014). The revolution also involves data-driven agricultural research, including that which uses data on plant genes (Carolan, 2020a; (Phillips, Relf-Eckstein, Jobe, & Wixted, 2019). It is argued that the current digital innovations in agriculture can solve global challenges such as food security and environmental concerns (Higgins, Bryant, Howell, & Battersby, 2017) through the well-targeted and strategic use of inputs and enhanced traceability (Busse et al., 2014).

However, with the expansion of digital technology use in agriculture and food production, there is evidence of emerging social and ethical issues (Bronson & Knezevic, 2016); (Gardezi & Bronson, 2019). Scholars warn limited studies have taken into account the complex structure of changes facilitated by digitally leveraged agriculture using an ecosystem view beyond the farm level (Klerkx, Van Mierlo, & Leeuwis, 2012a). There appears to be a mixed stance of optimism and anxiety among stakeholders who benefit from increased production and those who bear the disadvantages like increased digital dependences or lack of access to leading-edge technology in a potential digital divide (Carolan, 2020a). Social scientists have raised concerns such as privacy (Bronson, 2019), conflicts over data ownership (Bronson & Knezevic, 2016); (Wolfert et al., 2017) and power asymmetry between food system stakeholders (Bronson, 2018). Accordingly, ethical demands have been made by various stakeholders on aspects like activities of investors (Aksoy, Alkire, Choi, Kim, & Zhang, 2019), the development of novel regulations by the government (Wolfert et al., 2017); (Phillips et al., 2019), and demands for the inclusion of often-neglected social groups, such animal welfare advocates, in the field practice and within policy decisions (Eastwood et al., 2019). Within this social science scholarship, there are a variety of concepts used to describe the digital transformation of the field. Yet, each concept has a different scope of inclusion and implications for these ethical demands.

In this paper, we map different conceptualisations of digital technologies applied to agriculture and the resulting processes of digital transformation. Then, we apply the conceptual distinction of *digitisation* versus *digitalisation* to assess the value of each concept with respect to its ability to serve an ecosystem-based approach. Finally, we analyse the concepts based on their scope of inclusion in digital innovation in agriculture. We furthermore argue for *digital agriculture* as a robust, overarching concept because it helps to account for the full ecosystem implications of innovation-induced shifts and thus serves an ethical transition in the agriculture innovation system.

Taking an ecosystem view on digital agriculture

The term ecosystem is used in the context of innovation studies to refer to the dynamic interaction between economic and non-economic stakeholders involved in technology development and practice (Dini, Iqani, & Mansell, 2011). The innovation ecosystem is the transformative environment in which different stakeholders can innovate and interact (Li, Badr, & Biennier, 2012); (Pappas, Mikalef, Giannakos, Krogstie, & Lekakos, 2018). Taking an ecosystem view on technological change allows for analysis beyond economic assessments, to account for social and political outcomes from emergent technologies (Li et al., 2012). (Acs, Stam, Audretsch, & O'Connor, 2017). Therefore, innovation ecosystem scholars have applied the concept to emergent technologies in agriculture and argued that technologies should not be treated as discrete innovations but should be assessed as part of the agricultural innovation system (AIS) (Fielke et al., 2019). Digital innovations, viewed through an AIS lens, can be recognised as being the result of multiple interactions among farming systems components, including supply chains, economic systems, policy environments and other societal stakeholders (Klerkx et al., 2012a). Taking an AIS view, some scholars have highlighted the potential societal implications of digital tools applied to agriculture and food (Klerkx, Jakku, & Labarthe, 2019); (Schut et al., 2015). Scholars argue that the conceptualisation of innovation systems applied to the agricultural sector is still at its early stages (Fielke et al., 2019); (Rose & Chilvers, 2018). However, adopting such a systemic perspective will encourage innovators to understand the inter-relationship between coexisting innovations of the field and it will facilitate the ethical distribution of responsibilities among stakeholders (Rose & Chilvers, 2018).

Thus, while traditionally the purpose of the term "innovation ecosystem", as used by the private sector, was in relation to achieving value maximisation from technologies, the contemporary concept of "ecosystem" extends to include normative need for private and public sectors and a broad range of stakeholders (Stam, 2015). Hence, we therefore have an ethical imperative as scholars to take an ecosystem view on digital-led shifts in agriculture as new technologies potentially have broad societal implications.

Concepts used to describe the societal implications of emergent technologies in agriculture

Various concepts are applied by social scientists who study digital agriculture with different implications. The interpretation of these implications can influence the technology-led social changes and ultimately how we manage complex social and technical shifts in the food system. There is a growing body of literature attending to different societal and economic dimensions of digital agricultural innovations (e.g., Bronson (2018); Carolan (2017), Eastwood et al. (2019); Higgins et al. (2017). This work reveals that digital technologies and innovations are likely to change the agricultural sector's operation and how it is managed (Holloway & Bear, 2017). Also, social scientists suggest that digital technologies and innovations used in agriculture are not isolated but evolve within a constantly changing system that includes various technological, social, economic and institutional dimensions. Consequently, it includes stakeholders from all these areas (Klerkx, Van Mierlo, & Leeuwis, 2012b). Such a broad system view involves complex stakeholder issues such as potential consumer refusal of digital innovations, unequal allocation of costs and advantages within farming communities, detrimental socio-economic impacts of increased technology adoption (e.g. labour displacement), ethical threats of data gathering and ownership and exchange of digital data (Wolfert et al., 2017); (Regan, 2019). Proponents of digital innovations believe that big data, intelligent machines, robotics, and the internet of things could play an important role in achieving enhanced productivity and greater environmental efficiency in food production by enabling precise, economically, and environmentally sound decisions in agriculture (Rossel & Bouma, 2016). Although increased production is a valid argument, such a perspective mainly highlights technical interests and stakeholders concerned with farm-level productivity, economic gains, and labour efficiency. Thus, on the other hand, some social scientists argue that wider societal issues and stakeholders need to be taken into account (Rose & Chilvers, 2018) because while there are tangible benefits, there are likely potential socio-ethical issues (Eastwood et al., 2019). The latter perspective implies the inclusion of fundamentally different stakeholder groups in addition to the stakeholders highlighted by the proponents of efficiency.

The question which this paper asks is: which concepts for describing current technology-led changes in agriculture align best with an Agricultural Innovation System (AIS) approach and serve a variety of food system stakeholders and an ethical digital transition?

Methods: Terminology and concept mapping

We conducted a systematic review of peer-reviewed publications on digital technologies in agriculture to address this question. The study started with a collection of manually selected articles by leading authors in this scholarly area (e.g., Klerkx et al., 2019). Snowballing methods were used in a second stage to identify additional articles for the analysis using the bibliographies of the first works selected. As a result, a list of digital agriculture keywords (for example, precision agriculture, precision farming, smart farming etc.) were collected from the analysis of the initial datasets. These identified keywords were employed in data base searches and were combined with terminology relating to stakeholders used within the identified literature (for example, actor, player, agent and stakeholder) and terminology of the ecosystem (for example, network, system, agroecosystem, and ecosystem). The search queries were performed in Scopus as well as searched in Google Scholar to identify and select relevant studies for a final dataset for analysis.

Table 1 presents a summary of the applied concepts, and Figure 1 presents the systematic process.

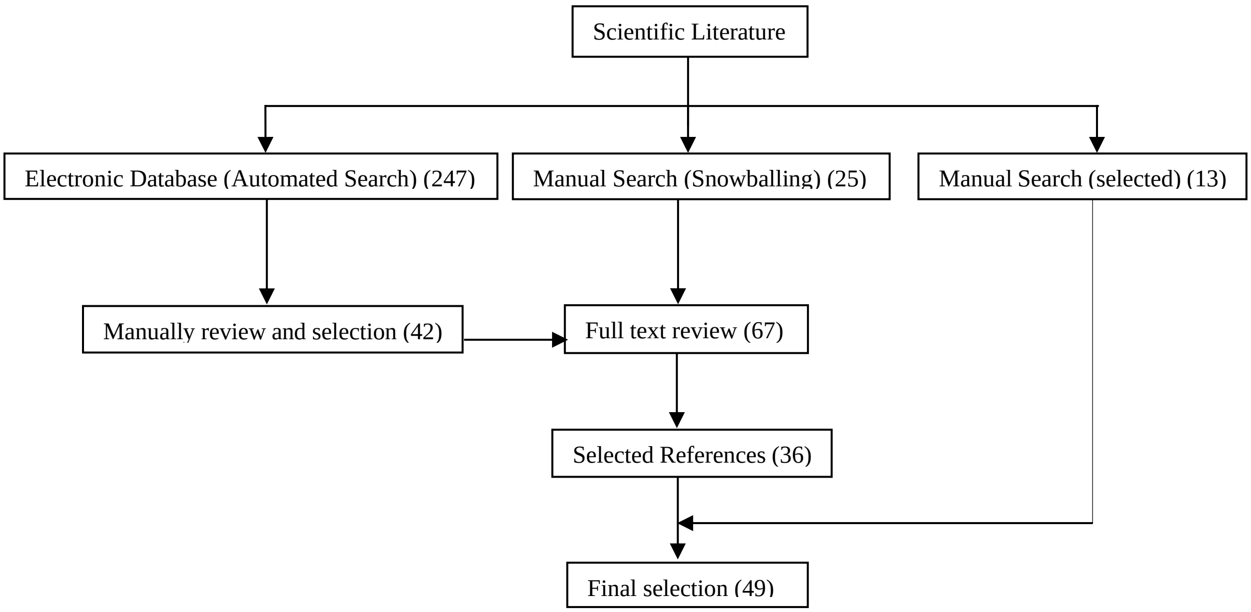

Figure 1. Systematic literature review process.

Results

Our analysis showed twelve concepts were applied most commonly to refer to studies of digital technologies in agriculture, including big data in agriculture, precision agriculture, precision farming, satellite farming, site-specific crop management, agriculture 4.0, farming 4.0, digital farming, e-agriculture, smart farming, smart agriculture, digital agriculture (Table 1). We noticed that some authors cited more than one term in their scholarship (either across different studies or within the same study) to refer to the concept of the application of digital technologies in agriculture. Also, some of these terms, such as “smart farming” and “smart agriculture”, were treated as synonyms by scholars. Most of the studies in our final dataset were published in the journals of *Precision Agriculture*, *NJAS-Wageningen Journal of Life Sciences*, *Frontiers in Sustainable Food Systems*, *Sociologia Ruralis* and *Journal of Rural Studies*. Further, the analysis revealed thematic and geographic clustering in the use of concepts. Themes were detected based on what the concepts were used to connote or what was studied through the use of the term, including production *and efficiency*, which includes five concepts, *technology platform/local communities*, which includes four concepts, and *social and societal*, which includes three concepts. Interestingly, we noticed that the concepts adopted by scholars differ based on the geographic location of the agricultural use case. For example, the term digital agriculture is preferred by scholars and case studies in Australia and New Zealand, whereas the term smart farming is applied in case studies in the European Union and Northern America. Less commonly, the term e-agriculture has been used to describe the technical application of digital technologies to agriculture in developing economies such as India (Chandra & Malaya, 2011); (Raj, 2013);(Rashid, 2014);(Nedumaran, 2020) and Kenya (Muriithi, Bett, & Ogaleh, 2009);(Namisiko & Aballo, 2013).

Table 1.
Summary of Concepts Applied to Describe Emergent Technologies in Agriculture within the Social Science Literature.

Term	Implication/Scope	Reference
big data in agriculture	production and efficiency	(Bronson & Knezevic, 2016), (Carolan, 2017); (Kamilaris, Kartakoullis, & Prenafeta-Boldú, 2017); (Wolfert et al., 2017); (Bendre et al., 2015)
precision agriculture	production and efficiency	(Busse et al., 2014); (Eastwood et al., 2019); (Gardezi & Bronson, 2019); (Bronson, 2019); (Higgins et al., 2017); (McBratney, Whelan, Ancev, & Bouma, 2005); (Regan, 2019); (Phillips et al., 2019)
precision farming	production and efficiency	(McBratney et al., 2005); (Eastwood, Klerkx, & Nettle, 2017); (Eastwood et al., 2019); (Phillips et al., 2019); (Wolfert et al., 2017); (Phillips et al., 2019); (Carolan, 2020a); (Busse et al., 2014)
satellite farming	production and efficiency	(Addicott, 2016); (Ahmad & Mahdi, 2018)
site-specific crop management	production and efficiency	(McBratney et al., 2005); (Řezník et al., 2016); (Ferguson & Rundquist, 2018)
agriculture 4.0	technology platform/local communities	(De Clercq, Vats, & Biel, 2018); (Rose & Chilvers, 2018); (Klerkx & Rose, 2020); (Zambon, Cecchini, Egidi, Saporito, & Colantoni, 2019)
farming 4.0	technology platform/local communities	(Clasen, 2016); (Zambon et al., 2019); (Braun, Colangelo, & Steckel, 2018)
digital farming	technology platform/local communities	(Bronson, 2019); (Eastwood et al., 2019); (Carolan, 2020a)
e-agriculture	technology platform/local communities	(Carolan, 2020a); (Nedumaran, 2020)
smart farming	social and societal	(Carolan, 2020a); (Eastwood et al., 2019); (Wolfert et al., 2017); (Higgins & Bryant, 2020); (Bronson, 2018); (Regan, 2019); (Klerkx et al., 2019); (Rose & Chilvers, 2018)

smart agriculture	social and societal	(Andrieu et al., 2019); (Bronson, 2018); (Klerkx et al., 2019); (Korotchenya, 2019); (Rose & Chilvers, 2018)
digital agriculture	social and societal	(Busse et al., 2014); (Bronson, 2019); (Carolan, 2020a); (Eastwood et al., 2019); (Klerkx et al., 2019); (Phillips et al., 2019)

In the following, we apply the theoretical distinction between digitisation versus digitalisation to discuss the agriculture concepts identified above with regards to their ability to capture the entirety of the digital agriculture ecosystem, societal dimensions, and a variety of stakeholders. *Digitisation* refers to the technical process of converting analogue data to a digital format (Brennen & Kreiss, 2014) to enhance internal efficiency (Gobble, 2018). This notion implies automating the existing processes enabled by digitised information (I-scoop, 2016). Therefore, digitisation is concerned with automatable internal systems, technical applications, and infrastructure-related efficiencies and does not necessarily relate to the surrounding environment or the broader ecosystem issues (Matt, Hess, & Benlian, 2015); (Legner et al., 2017). In contrast, *digitalisation* represents the next level of digital technologies. It connotes applying digitised processes to generate strategic and higher-level change (Gobble, 2018), for example, improving value delivery and enhanced business models via digital technologies (Jovanović, Dlačić, & Okanović, 2018). Digitalisation is enabled by information and communication technologies (ITC) that facilitate interaction with the surrounding environment. The ITC technologies, including the internet, have been described as the enabler of interacting with the rapid changes and new demands made outside of a business (Denner, Püschel, & Röglinger, 2018) and interacting with external stakeholders when they advocate for their particular needs (Prause, 2016). Thus, digitalisation has external implications that relate to the surrounding ecosystem and external stakeholders.

We describe below how the digital agriculture concepts are used by scholars and what conceptual dimensions of the agricultural innovation system are implied in these usages. We start by discussing the theme of production and efficiency, moving to technology platform/local communities, and *social and societal* theme. The concepts within each theme are discussed alphabetically, not based on their level of technology or their scope of AIS inclusivity.

1) Production and efficiency theme

This theme covers five concepts of *big data in agriculture*, *precision agriculture*, *precision farming*, *satellite farming*, and *site-specific crop management*.

Big data in agriculture

The concept of *big data* in agriculture is used to describe large scale agricultural data collection, aggregation, and analytics tools (Bronson & Knezevic, 2016), where data is applied as a basis for decision making (Wolfert et al., 2017). As used among scholars, the term big data tends to refer to technical contexts such as use of data to create fertilising crop maps (Bronson, 2018) and describe field features such as soil and climate (Carolan, 2017). While scholars argue the application of big data can have socio-technical implications (Wolfert et al., 2017); (Carolan, 2018b) in areas such as planning for climate change (Carolan, 2017), power relations among stakeholders, and unequal data ownership (Bronson & Knezevic, 2016); (Wolfert et al., 2017), the application of the term seems to be mainly focused on technical areas like assessing soil type, seed variety, weather and supply chain (Wolfert et al., 2017), and at their costs and benefits (Klerkx et al., 2019). Therefore, big data is arguably mainly applied in the context of production in the agriculture ecosystem, although more recently its usages are emerging in relation to consumption and retail (Carolan, 2018a). Sometimes, though less often, big data is not applied as an independent concept, but rather is used with broader concepts like digital agriculture or smart farming (Wolfert et al., 2017);(Bronson, 2018). Thus, from this perspective, big data in agriculture is mainly concerned with internal efficiency and classified under digitisation technologies.

Precision agriculture and precision farming

The concepts of *precision agriculture* and *precision farming* are generally used interchangeably (see Carolan (2017); Wolfert et al. (2017); Rose and Chilvers (2018); Eastwood et al. (2019), Klerkx et al. (2019); Phillips et al. (2019); Carolan (2020a)). Yet, our review shows the term precision agriculture is applied more frequently. The concept of precision agriculture is often associated with the transformation of production through saving on seed, fertiliser, chemicals (Johnson, 2012), enhancing managerial decisions, achieving higher yields, and mitigating environmental impact (Silva, de Moraes, & Molin, 2011); (Rose & Chilvers, 2018). The literature has identified different domains where this concept is applied. For instance, Busse et al. (2014) summarise three research domains: demonstrating profitability and positive environmental impact, studying the technical aspects, and implementation at the farm level. This categorisation connotes efficiency implications. Although scholars discuss the possibility of the broader impact of the concepts such as socio-technical (Bronson, 2019), socio-ethical (Eastwood et al., 2019), and socio-economic implications (Klerkx et al., 2019), the concept is mainly used in more technical analyses and within journals focused on the technical rather than the social dimensions. Thus, as used in the existing literature, the concept of precision agriculture is predominantly used to describe internal efficiencies, such as the enhancement of plant production from a technical perspective (Busse et al., 2014). This is especially true in scholarship, when the concept is discussed with big data (Carolan, 2017). This aspect of precision agriculture refers to big data collected through digital technologies that can better demonstrate the efficiency focus of the concepts. For example, data collection through sensors, the Internet of Things (IoT), robotics, drones, and global positioning systems (GPS) devices used in precision agriculture (Bronson, 2018); (Carolan, 2020a); (Higgins & Bryant, 2020). As a result, the concept's implications remain within the realm of efficiency and do not refer to the broader societal level. Thus, from this perspective, precision agriculture and precision farming are mainly concerned with internal efficiency and classified under digitisation technologies.

Satellite farming and Site-specific crop management

Concepts such as *satellite farming* (Addicott, 2016); (Ahmad & Mahdi, 2018) and *site-specific crop management* (McBratney et al., 2005); (Řezník et al., 2016); (Ferguson & Rundquist, 2018) appear in the literature though they are not frequently mentioned. The term satellite farming is used to refer to satellite and drone imagery of on-farm attributes such as weeds and soil (Klerkx et al., 2019); (Carolan, 2020a); (Phillips et al., 2019). As the terms themselves suggest, they are related to farm-level decision-making (Khanna, Epouhe, & Hornbaker, 1999), are discussed in production, and are concentrated on farmers and farm-specific decision-making (McBratney et al., 2005). Thus, these concepts have farm-level efficiency and production implications but do not readily relate in the extant analyses to broader ecosystem-level implications. Thus, from this perspective, satellite farming and site-specific crop management are mainly concerned with internal efficiency and classified under digitisation technologies.

2) Local communities and Technology platform(s) themes

Compared to the two other themes, this theme has relatively a lower frequency in the literature. It covers two sub-themes: *local communities*, which covered concepts of agriculture 4.0, farming 4.0, digital farming and e-agriculture, and *technology platform*, which covered the concept of digital farming.

Local communities: Agriculture 4.0, Farming 4.0 and E-agriculture

In some cases, the concepts of this theme, like *e-agriculture* and *agriculture 4.0,* are applied as synonyms for other concepts such as *smart farming* (see Carolan (2020a)). However, the concepts of Agriculture 4.0 and Farming 4.0 are often discussed as emerging phenomena of Industry 4.0. They are often associated with data collection, modelling and analysis along the supply chain for new forms of interaction and value creation (Braun et al., 2018). The concepts are applied in contexts such as enhanced application of water, fertilisers, and pesticides for green agriculture revolution with emphasis on the role of local communities, including collaboration between business and research communities (De Clercq et al., 2018) and functions related to local collaboration and production platforms (Braun et al., 2018). Particularly at the local level, the impact of these platforms is associated with concerns of power biases that favour influential stakeholders and disadvantage marginalised communities (Nally, 2016). Also, these concepts cover discussions of inequalities, such as concerns about the availability of required telecommunications infrastructure in rural areas (Zambon et al., 2019) and call for considering the impact on rural communities and the public highlighted in the context of agriculture 4.0 (Rose & Chilvers, 2018). Similar to agriculture 4.0, the concept of e-agriculture is discussed at the community level as a method to improve the livelihood of rural areas and platform effectiveness (Nedumaran, 2020). Yet, the analysis showed the concepts of agriculture 4.0, farming 4.0 and e-agriculture are adopted in certain geographic regions (see the results section). Thus, from this perspective, these concepts have external implications for inclusion in specific communities, therefore, can be classified under digitalisation technologies. However, they are often discussed in a certain geographic location with certain stakeholder groups (local and rural communities) which may limit their scope of inclusion.

Technology platform(s): Digital farming

The concept of *digital farming* is applied as a synonym of digital agriculture (see Eastwood et al. (2019)). However, some scholars, such as Carolan (2020a), used the concept in relation to digital platforms in agriculture like mobile devices, global navigation satellite systems, drones, robotics and precision irrigation platforms, as well as in relation to the users of the outputs of that platform, such as farmers. In some case studies, for example, *farmO* (Bronson, 2019), these platforms are described as open and easy to access (ibid.), and capable of encompassing diversified stakeholders such as farmers, firm leadership, programmers, engineers, agronomist and statisticians (Carolan, 2020a). Reviewing this sample of the involved stakeholders reveals the community-based nature and the focus on productivity and efficiency within the platform. On the other hand, these platforms often have commercial inferences (Bronson, 2019) and initiating them sometimes requires significant investment (Klerkx & Rose, 2020). The initial commercial investment implies the associated cost of accessing and using the platforms. Thus, those stakeholders in the ecosystem with no commercial interest (for example, social interests) are not connected or cannot be connected to these platforms (for example, due to the digital divide in terms of unavailability of the infrastructure in some areas), might be excluded. Thus, the digital farming concept (when taken into platform concept) has some external implications for inclusion in specific communities, therefore, is classified under digitalisation technologies. However, digital farming is often concerned with a community formed around a specific platform with limited scope for inclusion of non-economic stakeholders in the ecosystem.

3) Social and Societal theme

This theme covers three concepts of *smart farming*, *smart agriculture*, and *digital agriculture*.

Digital agriculture

The concept of *digital agriculture* is an umbrella term used in domains such as the digital agriculture ecosystem (Bronson, 2019). The concept is often used to discuss digital agriculture's alignment with internal productivity and efficiencies at the enterprise level as well as external implications such as transforming the agricultural innovation systems (Fielke et al., 2019). The discussion of this concept exceeds the farm and enterprise level to include production systems, value chains and food systems (Klerkx et al., 2019). As a result of relating to external systems, scholars suggest digital agriculture implications need to be observed over a broader regime and at landscape levels (Fielke et al., 2019). Therefore, in addition to shifting farming productivity, a digital agricultural system is said to shift external aspects to the farm, such as marketing channels (Phillips et al., 2019), property law, education policies, government policies, immigration, wellbeing, social justice, and so on (Carolan, 2020b). These external implications justify the need to move from a mere focus on production efficiencies to include broader ecosystem level concerns in scholarship (Bronson & Knezevic, 2016); (Eastwood et al., 2019). This framing of technology-led agricultural shifts is attracting more and more attention across the natural and social sciences and within policy circles (Klerkx et al., 2019). Thus, from this perspective, the concept of digital agriculture is concerned with internal and external implications and classified under digitalisation technologies.

Smart farming and Smart agriculture

The terms *smart farming* and *smart agriculture* are applied as synonyms (see Bronson (2018); Rose and Chilvers (2018). Yet, our review shows the term smart farming is more common. As with the concept of digital agriculture, in addition to improved efficiency and productivity, the concept of smart farming most often refers to broader notions beyond farm boundaries. Smart farming is often used in ecosystem-level discussions such as cyber-physical environment (Wolfert et al., 2017), value co-designing with other stakeholders (Andrieu et al., 2019), and inclusion of rights holders (Bronson, 2018). Therefore, smart farming is argued to potentially support broader societal benefits (Rose & Chilvers, 2018), including sustainability and rural communities' development (Regan, 2019). Also, the concept has been used to convey institutional and value implications within those communities that adopt digital technologies to agriculture (Carolan, 2018b). Thus, the smart farming concept makes room for studying the external environment conceptualised as an ecosystem of stakeholders involving diversified groups such as agribusiness, technology companies, venture capitals, start-ups, public institutions, universities, non-governmental organisations, farmers, consumers and actors from the civil society (Regan, 2019). Therefore, the concept of smart farming includes socio-ethical implications, which has attracted scientists' and policymakers' attention (Eastwood et al., 2019). Thus, from this perspective, smart farming and smart agriculture are concerned with internal and external implications and classified under digitalisation technologies.

Discussion: assessment of the concepts from an AIS perspective

Reviewing the concepts reveals their different scope of inclusion in agricultural innovation systems. Concepts such as big data in agriculture (when it is related to production), precision agriculture, precision farming, satellite farming, and site-specific crop management are one category of concepts that relate to the narrow concept of digitisation. Digitisation-related notions are mainly concerned with the internal operations of farm management with limited interaction with the broader ecosystem. For example, the concept of big data is related to technical issues such as which crop to plant, when to plant, when and where to cultivate (Carolan, 2017); or satellite farming and site-specific crop management as related to technical methods of field surveillance that are mainly concerned with optimising the use of resources. Similarly, concepts of precision agriculture and precision farming are associated with the usage of data collected about soil and crop conditions (Bronson, 2018) and mathematical models such as real-time climate predictions (Bendre et al., 2015); (Phillips et al., 2019). Such concepts are used to describe digital technologies applied to reduce costs, increase the ratio of output to input, and increase the yield in farming (Fielke et al., 2019). Therefore, the purpose of these technologies is described as efficiency, productivity, and sustainability improvements of agricultural processes (Phillips et al., 2019). This usage is in line with the definition of digitisation as it primarily relates to internal efficiencies and production, which remain at the farm level. Thus, this set of concepts focuses on the inclusion of stakeholders interested in improving productivity and efficiency but not necessarily the inclusion of social and societal stakeholders.

On the other hand, digital farming, e-agriculture, farm 4.0 and agriculture 4.0, digital agriculture, smart farming and smart agriculture are broader notions that relate to digitalisation. Here, we distinguish between agriculture 4.0, farming 4.0, e-agriculture, and digital farming that have platform-level (Carolan, 2020a) or local-level of implications (Raj, 2013); (Rashid, 2014), and the concepts of smart farming, smart agriculture, and digital agriculture. The impact of these latter concepts extends to ecosystem-level implications with challenges and opportunities for multiple stakeholder groups (Carolan, 2020a). Similar to the digitisation-related concepts, digital agriculture, smart agriculture, and smart framing concepts also imply the application of information and communication technology in farm management (Wolfert et al., 2017), therefore, encompassing the level of digitisation. Yet, these concepts demonstrate higher social and societal implications in the ecosystem context captured by digitalisation. For example, while precision agriculture focuses on in-field variability, monitoring and measuring farm-level data to enhance decision-making (McBratney et al., 2005), the concept of smart farming, in addition to farm-level technical issues, includes discussion related to governance and stakeholders beyond the farm boundaries (Higgins & Bryant, 2020). Therefore, the impact of smart farming, smart agriculture, and digital agriculture is more comprehensive and can encompass societal level implications. This level involves implications for sustainable economic development (Regan, 2019), overall sustainability (Wolfert et al., 2014), power and authority in food systems (Higgins & Bryant, 2020), innovation system disruptions (Fielke et al., 2019), value chains and food system shifts (Klerkx et al., 2019), and social and societal concerns (Carolan, 2020b). The external implications of digital agriculture and smart farming include various groups of stakeholders with different levels of power and authority (Higgins & Bryant, 2020). From this perspective, scholars have used digital agriculture, smart farming, and smart agriculture to emphasise the need to broaden the scope of "inclusion" in the context of farming (Rose & Chilvers, 2018) and for engaging the relevant stakeholders for better governance practices in society (Regan, 2019).

From an Agriculture Innovation System (AIS) perspective, concepts associated with digitalisation, such as smart farming, enable a higher level of stakeholder inclusion. Furthermore, these concepts are used to encompass diversified stakeholders and a broader set of social relations beyond the farm. Hence, digital agriculture, smart farming, and smart agriculture possess greater alignment with AIS scholarly analyses. However, between these concepts, the concepts of *digital agriculture* can more adequately convey the technological and innovative nature of the transformation. Thus, we argue for applying this concept as an umbrella term to studies of emergent technologies applied to food production.

Conclusion

Despite increasing awareness that the unattended socio-ethical issues related to the digital revolution in agriculture remain a matter of concern (Eastwood et al., 2019), digital innovations in software, hardware, robotics, drones, sensor technology and cloud storage systems continue to be implemented across the agriculture sector (Phillips et al., 2019) without diverse stakeholder involvement and with no clear ethical guidance on responsible practice. Such ethical guidance is expected to incorporate stakeholder expectations, needs, societal values, and ethical concerns (Eastwood et al., 2019). In the context of digital agriculture, value-based concerns may include the right path for how policymakers ought to handle issues such as privacy, use and ownership of information, sustainability, and human-related concerns such as justice, power, and control (Eastwood et al., 2019).

Understanding the needs and concerns of a wide variety of stakeholders in an Agricultural Innovation System is thus of top priority today (Busse et al., 2014); (Phillips et al., 2019). We argue that "digital agriculture" as a conceptual umbrella for scholarly analyses aligns with an AIS perspective and allows for examining a diverse set of stakeholders' views and concerns on emergent agricultural technologies and innovation (Eastwood et al., 2019).

Adopting an AIS view and inclusive incorporation of stakeholders into the digital agriculture ecosystem is particularly important as the emerging digital innovations in agriculture may lead to change in the entire notion of farming with consequences on the identity and cultural structure in agricultural communities (Holloway & Bear, 2017); (Bronson, 2019); (Carolan, 2017). For example, in addition to the possible change in the training requirements for farm staff and service providers (Eastwood et al., 2019), the demand to use new technology is not necessarily in line with the views of stakeholder groups concerning what it means to be a good farmer (Rose & Chilvers, 2018). These values-based mismatches can result in marginalised stakeholders (Higgins et al., 2017).

Highlighting these kinds of concerns in the ecosystem at the early stages of development and deployment of digital innovations could help policymakers avoid inadequate attention to the needs of stakeholders, which has led to harm in the previous cases, for example, the green revolution (De Schutter, 2015), the application of neonicotinoids (Dicks, 2013), and genetic modification (Macnaghten, 2015). In terms of genetically modified seeds, research has shown that these innovations have led to wider inequalities between farmers and large chemical corporations due to established legal regimes of the sector (Bronson, 2015). Therefore, scholars such as Eastwood et al. (2017) highlight the necessity of including all stakeholder groups such as technology companies, farmers, and local communities to maintain a responsible innovation process in the ecosystem. Such inclusion requires assessing the impact on the entire AIS, including on-farm, across farming landscapes, throughout the food chain, and on rural communities and the public as a whole (Rose & Chilvers, 2018). These complicated concerns cannot be easily captured in narrowly defined concepts like satellite farming or concepts like precision farming that mainly focus on technical issues.

There is a pressing need for ethical decision making in the digital agricultural transition. We have underscored the necessity of carefully choosing concepts that promote inclusion in the ecosystem. We call for applying concepts that move beyond analysing technical or economic issues only and allow us to envision a broader set of societal concerns and stakeholder needs. We argue that in the complex context of AIS, the concept of digital agriculture is desirable for the purposes of broader inclusion because it can encompass the ecosystem-level implications and involve stakeholders in the current agriculture system transformation as compared to concepts such as precision agriculture. Thinking carefully about scholarly discourse is crucial at this stage in the so-called digital agricultural revolution.

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Systematic Stakeholder Inclusion in Digital Agriculture: A Framework and Application to Canada

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Abstract: This study provides a model that supports systematic stakeholder inclusion in agricultural technology. Building on the Responsible Research and Innovation (RRI) literature and attempting to add precision to the conversation around inclusion in technology design and governance, this study develops a framework for determining which stakeholder groups to engage in RRI processes. We developed the model using a specific industry case study: identifying the relevant stakeholders in the Canadian digital agriculture ecosystem. The study uses literature and news article analysis to map stakeholders in the Canadian digital agricultural sector as a test case for the model. The study proposes a systematic framework which categorises stakeholders into individuals, industrial and societal groups with both direct engagement and supportive roles in digital agriculture. These groups are then plotted against three levels of impact or power in the agri-food system: micro, meso and macro.

Keywords: digital agriculture; inclusion; stakeholder; RRI; ecosystem; innovation; identification; categorisation

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1. Introduction

Agricultural production is deeply entangled within social, economic, environmental, cultural and technological systems. It is believed that digital agriculture will deliver benefits to society [1] and stakeholder inclusion can ensure these benefits are equitable to a broader range of society avoiding favouring already powerful stakeholders [2]. As noted in the introduction to this special issue, there are profound concerns about the social sustainability of agriculture, especially with regard to social and economic divides related to the commercialisation of farming. The transition to so-called "digital agriculture" [3] amplifies such concerns, potentially exacerbating inequities in the food system by creating divisions in access to or skill with computational technologies. Developing practices and policies that take into consideration the social and equity concerns of technological transitions in agriculture will require the meaningful inclusion of the perspectives of a diverse and inclusive group of stakeholders affected by the digital transition.

The field of Responsible Research and Innovation (RRI) has developed theory and methods relevant to the inclusion of stakeholders in innovation processes but it is arguably underdeveloped in its application to the agri-food context [4,5].

Responsible Research and Innovation (RRI) is defined as achieving mutual responsiveness between societal actors and innovations before (rather than after the fact of) commercialisation [6]. From a societal perspective, innovative technologies are capable of changing the social conditions of the environment in which they operate [7]. RRI thus places emphasis on neglected ethical considerations in the ecosystem context, such as inequalities [8]. Rooted in societal concerns and a desire to anticipate the implications of scientific research [4], the RRI approach is considered capable of enhancing innovation's social and ethical appropriateness through mitigation of socio-economic harm [9,10].

Based on their review of the RRI literature, Eastwood et al. [4] outline the conceptualisation of RRI into two main frameworks. The first framework encompasses the four principles of anticipation, inclusion, reflexivity and responsiveness which are also known as the AIRR framework. This framework is sometimes complemented with the fifth principle of transparency [4]. The second framework encompasses five elements: societal actor engagement, gender equality, open access, ethics, and science literacy and education. This framework is also sometimes complemented with the sixth element of governance [4]. The concept of engaging with a wide range of stakeholders is highlighted in this latter approach as a prerequisite to identifying and accommodating public concerns throughout the development process, and this then is best captured by the principle of inclusion [10]. The concept of inclusion and societal actor engagement both refer to stakeholders—where inclusion is leaning towards individual and commercial stakeholders—and societal actors' engagement which leans towards ecosystem-level stakeholders.

In this paper we apply the term "stakeholders" to refer to both elements of innovation and societal actors' engagement, which appear within the two RRI frameworks outlined by Eastwood et al. [4]. The concept of inclusion in the RRI literature is arguably more comprehensive than in other similar bodies of theory such as corporate social responsibility; this is in part because within RRI often stakeholder inclusion is meant to indicate attention to marginalised rights holders [8]. Yet, the conceptualisation of inclusion still needs further clarification in the literature to serve the various ways that societal stakeholders engage with technologies as well as various forms of stakeholder [5]. Justice, for example, is highlighted in recent studies as essential for the full characterisation of inclusive and responsible innovation [11].

Building on the Responsible Research and Innovation (RRI) literature and aiming to add precision to the conversation around inclusion in technology design and governance, this study aims to develop a framework for determining which stakeholder groups to engage in RRI processes. We developed the model using a specific industry case study: identifying the relevant stakeholders in the Canadian digital agriculture ecosystem. Being among the global leaders in digital agriculture [12], Canada has a fast developing digital agriculture ecosystem, and thus can be expected to have representation from most relevant stakeholder groups. Our study provides a foundation for systematic inclusion of a diversity of stakeholder groups by developing a framework for stakeholder identification and testing it against the Canadian context.

2. Responsible Research and Innovation and Stakeholder Inclusion

While RRI is intended to guide the development and introduction of responsible innovations [10], recent studies suggest there is more work needed to specify what we mean by the inclusion of stakeholder perspectives [4]. The literature emphasises the necessity of an exchange of views on the direction of technology development among stakeholders [7]. In some cases, studies outline the democratic but also the practical potential in collaboration among stakeholder groups—researchers, advisers and farmers—arguing that deliberation will enhance the chance of successful adoption of digital agricultural technologies [13]. However, there is little concrete guidance as yet concerning how in RRI processes one might identify the relevant stakeholders for interaction, which is arguably a precondition of inclusion.

While we acknowledge that in practice engagement of stakeholders has become more common in policymaking [4], our review shows that a systematic process or framework for stakeholder identification and inclusion remains to be clearly outlined. There is a tendency in the current literature to offer solutions for the mechanism of engagement with stakeholders rather than, as a first step, offering a means to identify and systematically categorise different stakeholder groups. The mechanisms currently highlighted for engagement include workshops, user-centred design, forums, embedding social scientists within inter-disciplinary projects, and meeting with stakeholders [1,4,5,14,15]. Carolan [16] has also noted that there is no method to follow when it comes to stakeholder identification in ecosystems other than “heterogeneous assemblage” [16]. To some extent, this may be a function of the heterogeneous nature of stakeholders in agriculture ecosystems [2,17,18]. Across several agricultural contexts, scholars have adopted snowballing techniques to identify stakeholders from early identification of most obviously relevant stakeholder groups [3,14–16,19–21]. Such an exploratory method is argued to facilitate the development of broad-based inclusion [15].

We build on existing guidance in the RRI literature in this paper, synthesising the literature (see Table 1) into a three-level hierarchical approach to stakeholder identification and analysis: micro, meso and macro. These levels correspond broadly to the economic and decision-making power of each stakeholder group. We combine this with a multi-thematic approach that categorises stakeholder groups into themes such as technical, social, and organisational themes [14]. Both of these are discussed in the following paragraphs.

Table 1. Summary of Stakeholder Analyses.

Reference	Research Domain	Methods & Geography	Research Objectives	Key Stakeholder Groups
Andrieu et al. (2019) [14]	Co-designing systems	Interviews Workshops Honduras	To present a seven-phase methodology to allow family farmers to co-design and adopt climate-smart agriculture (CSA)	Thematic categorisation • Technical • Social • Organisational
Busse et al. (2014) [18]	Innovation mechanisms	Interviews, Delphi Two-step survey Germany	Identification of barriers of the innovation processes	Themes with sub-categories: • Farmers/contractors • Input suppliers: agricultural engineering companies, seed companies, agrochemical industries • Public/private services: financial services, • soil sampling, yield mapping • Intermediates: unions, associations, media • Public and private research institutions and universities • Federal state departments and agricultural federal institutes • Public and private agricultural advisory Heterogenous assemblage: • Agriculture enterprise/farmers • Input suppliers • Services • Agriculture advisory services • Research • Associations • Food industry • Consumers • Food retailing • Policies/public administration • Legislation • Standard/certifications • International competition
Carolan (2018a) [22]	Socio-economic, governance	Interviews Consumer focus groups U.S.	How Big Data techniques and technologies govern our ability to imagine food worlds.	Thematic categorisation • Products • Retail • Habitus

Table 1. *Cont.*

Reference	Research Domain	Methods & Geography	Research Objectives	Key Stakeholder Groups
Carolan (2020a) [16]	Innovation pathways Governance	Interviews Field notes from participant observations U.S. and Canada	How to better incentivise adoption	Heterogenous assemblage: • Programmer • Engineer • Firm Leadership, e.g., CEO/Vice President/Director • Crop Specialist • Agronomist • Computational Biologist • Statistician • Farmers
Carolan (2020c) [23]	Innovation political economy	Interviews U.S.	Whether/how the digital signifier affects issues related to symbolic and material gentrification And land.	Heterogenous assemblage: • Farmer • Community organiser • Investor • Gadgets Entrepreneur: • Tech start-up • Restauranteur • Planner • Politician • Developer • Real estate agent
Eastwood et al. (2017) [24]	Innovation system	Interviews Australia	To identify potential collaboration To enhance innovation system functions.	Hierarchical categorisation • Farm level • Near farm • Global scales
Eastwood et al. (2019b) [4]	Responsible research and innovation	Interviews New-Zealand	To what extent, and why, have elements of RRI been considered to date to address socio-ethical challenges in NZ smart dairying development? What are the broader lessons for RRI application in smart farming?	Heterogenous assemblage: • Economics and Viability • Environment • Skilled people • Lifestyle and business • Community acceptance and connection • Animal welfare • Technology performance and infrastructure

Table 1. *Cont.*

Reference	Research Domain	Methods & Geography	Research Objectives	Key Stakeholder Groups
Fielke et al. (2019) [15]	Agricultural innovation systems (AIS)	Interviews Australia	How do innovation Communities perceive technology and policy in relation to a socio Technical transition toward the digitalisation of the Australian AIS?	Thematic categorisation • Culture • Markets • Industry • Technology • Policy • Science
Higgins & Bryant (2020) [21]	Governance	Interviews Australia	(1) how do meso-scale actors frame smart farming technology implementation (2) in what ways do those frames variously afford and/or constrain industry sovereignty over how technological change is implemented?	Heterogenous assemblage: • Agri-service providers • Agronomists • Consultants • Extension agents • Managers • Researchers
Klerkx et al. (2012) [17]	Innovation system Relation with policy and institutional	Conceptual No specific location	(1) evolution of systemic approaches to agricultural innovation (2) assessing key factors for innovation system performance (3) formulating an agenda for future research.	Thematic categorisation • Environment: Social, Political, Economic, Agro-climatic • Innovators • Farmers • Scientists
Klerkx et al. (2017) [25]	Co-innovation	Interviews, Document analysis, Interactive working session Denmark, France, Germany, Netherlands	(1) how do different Institutional conditions at different levels in four European countries influence the enactment of a shared set of participatory principles and methods by researchers and advisers working in the same international project? (2) how do differences and similarities in institutional conditions matter for the design of large international participatory research projects?	Hierarchical categorisation • Personal • Community and organisation • National agricultural innovation system (AIS)
Regan (2019) [1]	Socio-economic, governance	Interviews Ireland	Risks and benefits arising from the development of Smart Farming	Thematic categorisation • Subjective: Agtech Industry, Farming Representative • Mandated: Government/Policy, Support Agency • Objective: Social Scientist, Computer Scientist, Agricultural/Food Scientist

Table 1. *Cont.*

Reference	Research Domain	Methods & Geography	Research Objectives	Key Stakeholder Groups
Wolfert et al. (2017) [26]	socio-economic challenges	Conceptual No specific location	(1) What role does Big Data play in Smart Farming? (2) What stakeholders are involved and how are they organised? (3) What are the expected changes that are caused by Big Data developments? (4) What challenges need to be addressed in relation to the previous questions?	Heterogenous assemblage: • AgBusiness • AgTech players • Data start-ups • Farming Alliances • Farming cooperatives • Farms • Tech companies • Tech-start ups • Venture capital

Table developed by the authors 2020.

2.1. Hierarchical Categorisation

The hierarchical approach has been applied to capturing the stage of innovation within an RRI context [27], and in studies with ecosystem orientation in non-RRI bodies of work such as social innovation [28]. Typically, this approach refers to the three levels of micro (individual), meso (institutional) and macro (socio-political and macroeconomic) levels of analysis.

Micro-level stakeholder analysis is addressed in many studies on digital agriculture [3,18,29]. Emphasising the role of micro-level stakeholders, Phillips et al. [30] argue there is a strong bottom-up effort in researching digital agriculture innovations that are largely isolated from the global innovation ecosystem. Scholars acknowledge the importance of micro-level stakeholders. Rose et al. [7] assert that micro-level stakeholders such as farmers are the centre of change in the digitalisation of agriculture. Others highlight farmers' pivotal role in the adoption of digital agriculture innovations [2,31]. Despite their proactive role in innovation, the literature highlights how micro-level stakeholders are often omitted in the meso and macro level considerations. For example, scholars such as Bronson [29] point out a tendency among government-level stakeholders to invest in large-scale innovations driven by private sector which thus fail to support digital agriculture innovations suitable to or serving micro-level stakeholders.

Meso-level stakeholder analysis relates to service and other enabling stakeholders and is concerned with firm-level interactions and processes [28]. The meso-level includes industrial stakeholders such as consultants who are involved in the planning and implementation of digital agriculture [21], companies that are specialised in data management, as well as stakeholders such as regulatory and policy actors [26]. From a farm risk management perspective, farm advisories are considered by scholars to be a main stakeholder group [4]. From a leadership perspective, Stilgoe et al. [9] emphasise the role of research councils as key stakeholders in developing and implementing RRI principles and processes. From a service perspective, Busse et al. [18] remark on the role of service providers such as distributors and agriculture input providers. The meso-level is argued to be associated with inter-level interactions among stakeholders, particularly between meso- and micro-level stakeholders like farmers [32]. To overcome the differences among stakeholders, Higgins and Bryant [21] argue the necessity of understanding the stakeholders' negotiation processes and how stakeholders are connected at meso-level in an RRI context.

Macro-level stakeholders are the top-level stakeholders with the most power to effect change in the agri-food system such as governmental agencies and macro-level institutions like the World Bank [33]. Fielke et al. [15] argue that digital innovations need to be addressed as a component of an overarching context at the macro-level of analysis. Based on their subject of analysis, some studies outline the importance of macro-level stakeholders for the overall innovation ecosystem. For example, in the context of managing macro-level socio-ethical challenges, Eastwood et al. [4] argue for the leadership role of the government and other (macro-) top-level actors such as funding bodies to embed RRI and influence the R&D activities and innovation processes to enhance stakeholder engagement. [30] highlight the roles of government in generating policies and engaging in regulation. The role of institutions is argued to be crucial for the implementation of innovation platforms, strategy development and adoption processes [14]. The role of government is also discussed in terms of regulating access to data and privacy concerns [26,30].

While existing studies on digital agriculture include micro-, meso- and macro-level stakeholder analysis, the terms used to refer to these levels show variation even while the meanings remain consistent (see Table 1). For example, Eastwood et al. [24] applied a three-level hierarchical framework to analyse the role of private-public stakeholders. Their framework includes farm-scale analyses which spell out the interests of micro-level stakeholders, such as one-to-one training and advisory services for farmers. The near-farm analysis level spells out meso-level stakeholders such as service providers. The global scale analyses address the general adequateness of technology in farming systems. Eastwood et al. [24] explain the role of the public in a way that captures macro-level stakeholders' interests. In the context of co-innovation in agriculture, Klerkx et al. [25] apply a three-level hierarchical framework that includes a personal level encompassing micro-level stakeholders; a community and organisation level that encompasses meso-level stakeholders; and a national level that compasses the macro-level stakeholders. Although the framework developed by Klerkx et al. [25] can be applied to categorise stakeholders, their focus remains at the broader level of the agriculture sector in general, not digital agriculture specifically. Andrieu et al. [14] apply three dimensions—technical, social and organisational—in discussing co-design of digital agriculture systems with local stakeholders. The study includes three thematic dimensions concerning the interests of the three stakeholder groups, two of which can be listed according to the three hierarchical levels. The technical and organisational dimensions refer to meso-level stakeholders and the social dimension discuss micro-level implications for farmers. The study of Andrieu et al. [14] does not include macro-level stakeholders as the authors focus on local stakeholder engagement, and it does not expand to spell out technical and organisational stakeholders.

2.2. Thematic Categorisation

Reviewing the literature reveals that rather than the three-level approach we develop in this paper there is instead a methodological approach of thematic categorisation adopted more commonly. In this approach, themes are selected based on heterogenous assemblage, but similar stakeholders are categorised into relevant themes, such as technical, social and organisational [14]. For example, applying the RRI approach, identifies three thematic groups of subjective, mandated and objective stakeholders for digital agriculture. Carolan [22] identifies products, retail and habitus, and Fielke et al. [15] apply markets, industry, technology, policy and science categories. In terms of the taxonomy of themes, similar to the three levels of hierarchy, the same variation in terminology is observed for this categorisation of stakeholders. For example, studies such as [4,15,21–23,26] have all provided a list of involved stakeholder groups for their studies, but they do not apply similar labels to groups that might be considered similar. In particular studies such as [1,17,18] group stakeholders into themes but label the themes differently. We build on this literature to adopt a three-level thematic approach for the proposed framework where similar stakeholders are grouped into the same thematic category.

3. Framework and Discussion

The stakeholder inclusion framework presented here has two dimensions. The basis is a distinction between three types of stakeholder groups—individuals, industry and ecosystem stakeholders—and more specifically, for each group we distinguish stakeholders with direct engagement in digital agriculture and those with supportive roles. The framework then highlights that each stakeholder group may have impacts on one of three levels—micro, meso and macro. The framework is presented in Figure 1 (numbers in brackets show results from the validation case study presented below).

Impact level	Individual Actors: directly engaged in Dg Ag	Individual Actors: supportive interests	Industry Actors: directly engaged in Dg Ag	Industry Actors: supportive interests	Societal Actors: directly engaged in Dg Ag	Societal Actors: with supportive interests
Macro Level	• Lobbyists	• Politicians • Economists • Social Scientists	• International competitors	• Finance (6/41)		• Academia (5/43) • Government/Policy (14/106) • Government-International (5/47) • International Institution (2/12) • Media (3/29)
Meso Level	• Firm leadership • Consultants/ advisors	• Ag Scientists • Computer Scientist	• Ag Enterprise/Farming Business (4/33) • Ag Equipment (12/98) • Ag Inputs (14/795) • Ag Supplier • Ag Technology (12/597) • Agri-service providers • Consultancy firms (5/35)	• Food Manufacturers (1/6) • Infrastructure-IT (1/10) • IT Solutions (5/27) • Insurance (1/5) • Venture capital (1/16) • Wholesalers (1/11)	• Associations (1/27) • Farming Representatives • Science & Technology Development (1/13)	• NGOs
Micro Level	• Farmers • Programmers • Engineers • Innovators • Computer Scientist • Investors (individuals)	• Customers	• Food retailing • Other retailers (cannabis) (1/6)		• Cooperatives (1/12)	• Community organisers • Animal welfare advocates

Stakeholder Group

Figure 1. Framework for Systematic Stakeholder Inclusion. Figure developed by the authors 2020.

3.1. Individual Stakeholders

3.1.1. Micro-Level Impact

The first category of the model includes individual stakeholder groups with micro-level impact like farmers, programmers, engineers, innovators, computer scientists, and investors. Farmers represent key individual stakeholders with a direct interest and engagement in digital agriculture but with limited impact on the current innovation ecosystem. In the context of digital technologies, compared with other stakeholders, farmers are usually considered among the least powerful stakeholders. At the same time, in the literature farmer impact is analysed and discussed at the farm level as being the baseline of technology adoption [4]. In the context of adoption, the farmer's role is acknowledged as an impediment since digital agriculture innovation may be resisted by farmers who are reluctant to adopt [4]. This group of stakeholders face several challenges. For instance, to an extent, it is said that digital agriculture innovations may be substituting farm labourers [8]. Based on a set of survey studies, Bronson [29] concluded that despite the potential of digital agriculture, not all farmers are enthusiastically engaging with digital innovations. It is suggested that due to the deskilling of humans [34], farmers are losing degrees of decision-making capability in reference to digital agriculture. In some countries, this group is argued to have a tense relationship with other digital agriculture stakeholders such as private companies [4] or to have a lack of awareness that impacts the adoption of digital agriculture [35]. Ref [2] outlined farmers' challenges as overlapping decisions between commercial, biophysical limits and new farm practices. Despite their currently marginal power status, the literature highlights the necessity of farmers' inclusion in different aspects of digital agriculture within the RRI approach.

Other stakeholder groups of this category include customers, programmers, engineers, innovators and investors. Similar to farmers, these stakeholders have a micro level of impact. For example, while customers' values are considered the optimum goal of chain systems [26], there is no clear method developed for customer inclusion outside of market based strategies like focus groups which concentrate on the goal of private gain/commercial success. Hence, we categorise consumers among stakeholders with supporting roles and not among those with direct engagement in digital agriculture. Investors are increasingly required to consider the ethical and societal concerns of other stakeholders in their decision-making [28]. Individual investors can have an impact on meso-level stakeholders such as by funding new digital agriculture start-ups [26], yet we argue the impact of the private investor will remain at the micro level as it is less likely this group of stakeholders can make a vast and diversified investment that has an impact on the sector at meso level. Another stakeholder group of the meso level includes innovators. Innovators are argued to not always receive a proportionate return on their efforts [30]. Nevertheless, investors and innovators are gaining importance in the RRI approach [27]. Engineers and other expert individuals such as software developers have a recognised role in developing digital agriculture innovations [16,18]. Although the inclusion of individual experts in the RRI approach is imperative [8], we argue their impact stays within the micro level, namely at the farm level, as their scientific efforts are largely dictated by firm level goals and commitments [29].

3.1.2. Meso-Level Impact

In the category of individuals with meso-level impact, stakeholders such as individual consultants and firm leadership have more direct engagement and interest in digital agriculture. Although the literature highlights the role of all level of mangers as important for RRI [11], case studies are centred on the role of senior-level executives and middle managers in digital agriculture [22]. Scholars such as Carolan [16] use the term "leadership" to refer to this group of stakeholders. Farm managers are argued to be responsible for production [36] and thus have the power to leverage the capability of digital technologies towards a digital transformation in agriculture [16]. The main challenge facing this stakeholder group in the RRI context is to make long-term projections towards environmental and social practices and set RRI Key Performance Indicators (KPIs) to monitor outcomes [37]. Independent consultants and farm advisors are individual meso-level stakeholders with a recognised role in managing digital agriculture uncertainties [21]. Scholars posit this group ought to lead responsible innovation and thus they have to be involved in discussions on the future of digital agriculture [5].

Certain researchers are described as having meso-level impact—those which contribute to defining policies on the farm [14]. These actors are recognised as those that can change the focus of the industry such as the recent shift from innovation adoption research that prioritises the agency of farmers [7]. With the expansion of participatory processes in digital agriculture, academic researchers can understand and outline the associated implications and provide a platform for RRI exercises and thus the input of a host of stakeholders [4]. Further, to interact with other stakeholders, researchers are expected to transform their identities, roles and routines and develop new skills to be effective in these contexts [25]. Another stakeholder group in this category includes agricultural and computer scientists. These stakeholders are involved in knowledge and technology development [38], including in developing solutions for testing and monitoring specialised aspects of farm monitoring such as on fertilisers and nutrients [36]. There is currently a call for bottom-up, self-governing science and laboratory practice that may lead to further impact among this group [29]. We argue at present, without the support of other stakeholders such as policymakers, the impact of these stakeholders cannot reach to the macro level.

3.1.3. Macro-Level Impact

Our analysis of news articles and literature (Table 1) did not yield individual stakeholders with macro-level impact. However, we list lobbyists as possible stakeholder groups falling into the category of individual stakeholders with direct engagement in digital agriculture. The role of lobbyists is recognised in food-related industries in terms of creating legitimacy [24], influencing societal agendas and advocating particular technological solutions [17]. Thus, the impact of this group of stakeholders can expand to include macro-level influence. The role of lobbyists in digital technologies likely includes work on sensitive issues such as the labour market, as well as the migrant/immigrant workforce, in agriculture [39]. Scholars often highlight the negative impact of lobbyists as a possible abuse of power by this group in areas such as genetically modified organisms (GMOs) [26]. Politicians are a group of individual stakeholders concerned with and having power over macro-level interests in areas such as public health [40], hence they have a supportive role in our framework. The acceptance of politicians, together with NGOs and users, is argued to be vital for digital agriculture expansion [41]. In the same category, economists are another group that did not appear in our analysis of the news, but we know from other technological areas related to agri-food that economists play a role in identifying RRI-related issues such as inequalities in the ecosystem [42] as they outline the future outcomes of technology-led societal changes [43]. Thus, we argue that economists are an important group that needs to be taken into account in the innovation ecosystem. Certain key researchers that point out concerns regarding the impact of digital agriculture on the inclusion of marginalised stakeholders can play a role in highlighting the macro-level political and economic concerns that influence digital agriculture development and implementation [21]. Policy-relevant sociologists or researchers are thus included in our model.

3.2. *Industrial Stakeholders*

3.2.1. Micro-Level Impact

Food retailers are the first category of industrial stakeholders with direct engagement and interest in digital agriculture and micro-level impact. Despite their potential role in supporting and promoting digital agriculture [21,31], industry experts consider these groups of stakeholders rather unimportant [18]. While the application of digital technologies, such as big data analytics, is well-discussed in agriculture, consumption and retail have lagged behind [22,44] and their impact remains limited to the micro level. This stakeholder group can provide support for consumption and customer inclusion by providing platforms for sharing views [30] and thus they ought to be integrated in RRI discussions.

3.2.2. Meso-Level Impact

Our analysis shows the vast majority of stakeholder groups are industrial stakeholders with meso-level impact. Stakeholders of this category were extracted from the news analysis.

The category of industrial stakeholders with meso-level impact and direct engagement in digital agriculture activities includes many large enterprises. These stakeholders are sometimes referred to as service providers with direct interest and engagement in digital agriculture [18]. These actors play a key role in digital agriculture and their activities are considered central. For example, field experts outline agricultural enterprises with agriculture technology as the most important stakeholder groups for leading innovations in the field [18]. However, these often-large agriculture enterprises are sometimes criticised for exploiting their market dominance to promote the adoption of certain technologies at the expense of smaller enterprises [4,8,18]. This power seems to be rooted in the particular infrastructure of the agriculture sector; it is argued most of the agri-food infrastructure-like storage facilities, processing and transportation in the developed countries, including Canada, are designed to serve large-scale production [40]. This has resulted in the dominance of the large agri-food players who can control the ecosystem and veto change [30,40]. Hence, including these large stakeholders in discussions with other stakeholder groups, such as farmers, is required to exchange feedback and to reach a mutual understanding in the field [8,18], yet may represent particular challenges with regards to trust and disclosure of trade secret information.

The meso-level category also includes stakeholders such as agriculture enterprises that focus on mass-producing or acquiring crops as commodity and commercialisation activities. Agriculture equipment enterprises are stakeholders that provide machinery used at different stages of digital agriculture. Agricultural input suppliers are considered a traditional stakeholder group [26] that provide the necessary inputs such as fertilisers, pesticides, chemicals, seeds, crops and livestock care and who advise on the needed tools and technologies for production as well as other aspects of digital agriculture. Agriculture equipment and machinery are increasingly becoming digitally connected and act as a source of data collection for planning [16,26]. Hence, this stakeholder group is gaining more importance in policy-related discussions such as food security and sustainability [26]. However, scholars also note digital or "precision" equipment is becoming too complex for many farmers in the existing farming system [2]. Agriculture technology stakeholders also includes enterprises that provide digital technologies such as sensors, data processing solutions, big data analytics, global positioning systems (GPS), map and image processing theologies. Several consultancy companies assist industry with the different skills required by digital agriculture practice on issues that can influence other stakeholders [4]. The role of consultancy companies is regarded as intermediary in the translation and exchange of knowledge for problem-solving and innovation [17]. Compared to research organisations, advisory services are considered to create institutional contexts that are conducive to co-innovation with other stakeholders [25]. However, digital agriculture is transforming the role of consultancy companies and exposing them to new challenges in proving effective supports to farmers [21]. Consultancy enterprises are now required to deliver advisory services based on information and knowledge at the farm level in its local-specific context [26]. This role transformation is argued to be a challenging process [45] that consequently may impact other stakeholders.

The other industrial stakeholder with meso-level impact are companies that do not directly engage in digital agriculture activities but provide the necessary support required for the success of the digital agriculture ecosystem. This group includes food manufacturers, wholesalers, venture capitalists and insurers. Food manufacturers, similar to other stakeholders like retailers, are adopting digital technologies and innovation to collect data on consumption patterns [46]. While the customer becomes more aware and sensitive towards issues like GMOs, it is argued that digital agriculture serves this interest by enabling more food traceability and transparent production [1]. Thus, this group of stakeholders links the interest of social and societal stakeholders with stakeholders on the industrial and production side. Consequently, this can empower and engage micro-level stakeholders such as consumers with other groups [1]. One possible challenge for agri-food producers is the availability of machinery that may not be optimally tuned to local needs and expectations which can, in turn, mitigate their social value [30]. Due to their role in linking different stakeholders and supporting societal values, we advocate for including this group in an RRI approach. At the same level, the category of supportive actors includes Information Technology (IT) solutions groups which provide applied technologies to digital agriculture and IT infrastructure groups that provide the required infrastructures of IT services. Since most of the digital agriculture technologies and innovation rely on IT-based platforms, the role of these enterprises becomes vital in this field [47]. Technology and specifically Information and Communication Technologies (ICT) are considered a priority topic in the agri-food sector [1]. Aspects such as open-source ICT development, data movement between platforms and protection of farmer privacy are deemed crucial in the RRI context [4]. The wholesale stakeholder group represents an enormous buying power in the ecosystem. It is argued that wholesalers can grow to form monopsony conditions where only a few powerful buyers leverage their bargaining power over less powerful stakeholders such as farmers [19]. Thus, including this group of stakeholders becomes necessary for RRI practice. Venture capitals are considered another key stakeholder in the digital agriculture ecosystem [1]. Venture capitalists, in addition to funding digital agriculture businesses [30], play a role in ensuring the interests of other stakeholder groups such as investors and social stakeholders [27]. Scholars posit venture capitalists are now increasingly interested in investing in agriculture technology companies [26] and we argue this group play a crucial role in the field and must be included as a key stakeholder group. Insurance companies or insurers is another stakeholder group with a supportive role. Insurers supports digital agriculture by developing information-based business models for risk management [3]. They also play a role in data acquisition and sharing as well as alliances with international insurers [30].

3.2.3. Macro-Level Impact

In the category of industrial stakeholders with macro-level impact, we listed international competitors as stakeholders with direct engagement in digital agriculture and finance enterprises as stakeholders with supportive roles. International competition is considered a motive for innovation [18] as it can lead to product development and innovation pipelines [48]. However, although international competitors represent a powerful macro-impact on the entire ecosystem, scholars argue that in the long-term the main competition remains at the micro level/local level over land, labour and capital [30]. In the context of competition, participation in an RRI approach can be beneficial for competitors and environmental analysis [11]. And due to international competitors' roles in shaping local competition, we included this group of stakeholders in our proposed model. Finance stakeholders play a central role in funding digital agriculture projects. Our news analysis yielded stakeholders like banks and investing agencies. Scholars assert that digital agriculture needs large capital investments that can influence the adoption decision [1,31]. Capital can substitute framers' knowledge and downgrade their role on the farm [2]. From this perspective, this group's activities have social implications with macro-level impact and we argue for including this group.

3.3. Societal Stakeholders

3.3.1. Micro-Level Impact

The category of stakeholders with societal objectives and direct engagement in digital agriculture includes cooperatives. The role of cooperatives is acknowledged in supporting local growers and workers, and also helping farmers connect produce to local markets [49]. From this perspective, we argue their impact is limited to micro-level analysis. The category of micro impact and mandated stakeholders with a supportive role includes actors such as community organisers and animal welfare advocates. Both stakeholder groups are argued to be often neglected in digital agriculture discussions [4]. Hence, we include them in our proposed model and call for better inclusion of these stakeholders in the RRI approach in digital agriculture.

3.3.2. Meso-Level Impact

The category of stakeholders with meso-level impact and direct engagement in digital agriculture includes associations, farming representatives and science and technology development agencies. Our literature analysis did not yield adequate discussions of the role of associations. One possible reason for this dearth of coverage in the literature suggests associations are not involved in innovation activities and rather pursue other mandated interests of their respective stakeholders [18]. However, since this group of stakeholders is directly engaged in digital agriculture by representing the interest of industrial players, we advocate including it in the RRI stakeholder inclusion model. Farming representatives have a direct engagement in digital agriculture and possess experiential knowledge of the topic [1]. The inclusion of this group is considered pivotal for future discussions about the direction of the industry and the exchange of views with other stakeholder groups [7].

At the same level, Non-Governmental Organisations (NGOs) are considered a stakeholder group with a supportive role. However, this group did not emerge from the analysis. NGOs are known to play a facilitating role in securing other stakeholders' interests [14] and this group can question the RRI processes and advocate for societal interests [27]. Based on their objectives and characteristics, the impact of NGOs can vary from micro level [14] to macro level [28]. NGOs are among the stakeholders that can influence the success of digital agriculture [41]. Thus, we consider NGOs a key stakeholder group and list them in the meso-level analysis in the proposed stakeholder categorisation model. Since the impact of NGOs is size-sensitive, not every NGO can influence the macro-level discussion. On the other hand, those that have such capacity can be considered an international institution and would be placed in the macro-level category.

3.3.3. Macro-Level Impact

Our analysis did not capture societal stakeholders with direct engagement in digital agriculture at the macro level. This could be due to the political–economic structure of Canada. Yet, the macro-level category includes mandated stakeholders with a supportive role such as government and policy stakeholders, academia, media and international institutions. Academia and other research institutes are concerned with delivering long-term and fundamental research and are considered the most important among the non-firm stakeholders [18]. In developed countries, academia in collaboration with the other ecosystem's stakeholders such as political actors is expected to contribute to the development of technological and social innovation [50]. Government and policy stakeholders represent a wide range of players. These stakeholders are considered to be capable of providing strategic insight into digital agriculture [1]. Thus, in the context of an RRI approach to digital agriculture, there is a necessity of policy leadership [4]. This leadership role is concerned with facilitating policies and mechanisms, engaging in privacy and regulation issues and providing cybersecurity at the national level [30]. However, despite having a democratic mandate to ensure societal wellbeing, biased investment practice by government stakeholders has been shown to be promoting large-scale industrial farming at the expense of other food production strategies and actors [8]. This bias is due to the influence of industry stakeholders such as designers and scientists on the government and funding agencies compared to the influence of stakeholders outside the industry [29]. On the other hand, governmental practice in areas such as environmental protection laws or product and process traceability can spur innovation in digital agriculture [18].

Media are involved in public inclusion activities by linking digital agriculture with wider public stakeholders [4]. In recent years, due to advances in telecommunication technologies, the traditional concept of media is transforming towards more interactive platforms of communication like social media. There is evidence that big data acquired through social media analysis and web cookie tracking are applied to model patterns of behaviour, consumption, views and opinions on sensitive societal issues such as elections [51]. Some digital agriculture stakeholders have already developed methods for food marketing and managing consumer interests through social media analysis [46]. Scholars argue that these data practices may lead to privacy and ethical concerns by non-media stakeholder groups like consumers and the government [29]. Thus, we argue that the impact of this group can influence the entire ecosystem.

In the same category, two groups of international government and international institutions represent macro-level stakeholders with supportive roles. The importance of including foreign governments lies in their impact on international institutions and international competition, and this is especially true for countries like the United States of America (USA) that wield considerable global power. Hence, we argue for including these governments as a stakeholder group. International institutions include stakeholders such as the Intergovernmental Panel on Climate Change are recognised as enhancing innovation in the agriculture context [17]. These stakeholders have interests that transcend the national level to include global-level issues such as the demand for a more just and sustainable food system [52]. While these stakeholders influence digital agriculture, the expansion of digital agriculture is also transforming the role and power leverage of these institutions [3]. In the context of responsible innovation, these institutions are now often required to move beyond compliance with established regulation to cover international objectives such as global warming and climate change [14]. We argue that a powerful stakeholder like the European Union (EU) can have an impact on the entire ecosystem of digital agriculture in non-European countries by demanding a higher level of standards in business transactions that set a standard for practice elsewhere. Thus, we advocate the inclusion of this group in the stakeholder categorisation model.

4. Application: Canada's Digital Agriculture Stakeholders

4.1. Application Context

To validate the framework and exemplify its application, we present the case of digital agriculture stakeholders in Canada.

At present, Canada is acknowledged as a leading country in terms of efficiency of digital agriculture [12], and Canadian farms are among pioneer farms from the USA, Europe, Australia and China in embedding digital technologies in agriculture [53]. The Government of Canada has approached the application of digital technologies in agriculture as a driver for societal wellbeing [54], which suggests that one can expect even greater development of digital agriculture practices in Canada over the coming years. Further, the Canadian government is currently supporting research relating to the next wave of digital technologies, including Artificial Intelligence (AI) with substantial investments, relating to agriculture. The application of "responsible" AI has been recently highlighted at the top level of policymaking in Canada [55] but with less guidance on what this means in practice. This type of guidance is expected to incorporate societal values, needs and expectations [4]. In the context of digital agriculture, these may include solutions to issues such as privacy, use and ownership of information; sustainability; human-related concerns such gender, minorities, justice, human values, power and control concerns; and impact on international relation concerns [4]. Solutions necessitate pressing efforts to inform policymakers, funders, technology companies and researchers about the perspectives of a wide variety of stakeholders towards digital agricultural innovations. These social forces on policy and industry efforts are argued to be beneficial at both productivity and efficiency, and ecological levels [31].

4.2. Application of Materials and Methods

The focus of the case study is to identify the main stakeholders in the Canadian digital agriculture ecosystem and algin them with the framework presented above. To this effect, we analysed the news coverage of digital agriculture in Canada with the purpose of identifying organisational stakeholders, applying natural language analysis methods.

The base data set is extracted from the news data base Factiva (Available online: http://www.factiva.com/sources/facts.asp (accessed on 20 September 2020)), using keyword searches related to digital agriculture. Factiva is a leading database including worldwide, full-text coverage of news [56], and it includes both leading national newspapers and smaller regional publications. Print media remain an important avenue of public discourse and continue to be utilised for discourse analysis and similar text-based studies [57].

We focused on digital agriculture news published by Canadian media over the last 10 years. This timeframe reflects the emergence of digital agriculture within the past decade [12]. The timeframe covered the period of 1 January 2010 to 20 September 2020 (the date of performing the query). The query yielded 2581 results, 843 of which were duplicate news articles and 1698 articles were unique.

To extract the key organisational stakeholder, we apply text mining algorithms provided by Factiva to extract the most cited entities within the results. A summary of the top 100 entities is given in Table 2. The entities were manually reviewed in their related news contexts to ensure their relevance to digital agriculture. At this stage, two entities were removed.

Table 2. Media Analysis Results—Canadian Digital Agriculture Stakeholders.

Entity	Freq.	Entity	Freq.	Entity	Freq.	Entity	Freq.
Agrium Inc	421	Land O'Lakes Inc	12	United States Department of Agriculture	8	The Bank of Nova Scotia	5
AgJunction Inc.	329	University of Guelph	12	Western Economic Diversification Canada	8	Brock University	5
Nutrien Ltd.	134	GVIC Communications Corp	11	Canadian National Railway Company	7	European Union	5
Bee Vectoring Technologies International Inc.	104	Mitsui & Co Ltd	11	Canadian Space Agency	7	Innovation, Science and Economic Development Canada	5
Deveron Corp.	80	Raven Industries Inc	11	Dalhousie University	7	Novozymes A/S	5
Braingrid Ltd.	71	Accenture PLC	10	ICL Group Limited	7	OmniEarth, Inc.	5
		TELUS Corp	10	Intergovernmental Panel on Climate Change	7	Ontario Securities Commission	5
Government of Canada	44	Clean Seed Capital Group Ltd.	10	ING Groep NV	7	PartnerRe Ltd.	5
Monsanto Company	43	NovAtel Inc	10	Beyond Meat Incorporated	6	Input Capital Corp.	5
UrtheCast Corp	35	Glacier Media Inc.	10	CubicFarm Systems Corp	6	AGCO Corporation	4
Association of Equipment Manufacturers	27	Trimble Inc	10	Pond Technologies Holdings Inc.	6	The Andersons Inc	4
Agriculture and Agri-Food Canada	23	China Ministry of Commerce	9	Namaste Technologies Inc.	6	Beijing Unistrong Science & Technology Co., Ltd.	4
The Climate Corporation	23	Buhler Industries Inc	9	RBC Dominion Securities Inc	6	Calian Group Ltd.	4
Deere & Company	23	Affinor Growers Inc.	9	DuPont de Nemours Inc.	6	Cargill, Inc.	4
Competition Bureau Canada	21	Patent and Trademark Office	9	Intrinsyc Technologies Corp	6	DigitalGlobe Inc.	4
Novariant Inc	20	Avrio Capital Inc.	9	Kubota Corp.	6	Draganfly Inc	4
Bayer AG	18	Ag Growth International Inc	8	Maxar Technologies Inc.	6		
Federal Trade Commission	17	Arab Potash Co Ltd	8	Magna International Inc	6	Export Development Canada	4
BASF SE	16	Health Canada	8	Merrill	6	Hexagon AB	4
Transport Canada	16	Canadian Radio-television and Telecommunications Commission	8	Netafim Ltd.	6	Environmental Protection Agency	4
Village Farms International, Inc.	16	Farms.com, Ltd.	8	CNH Industrial N.V.	6	ImagineAR Inc.	4
Kleiner Perkins Caufield & Byers	16	Mahindra & Mahindra Ltd.	8	Rocky Mountain Dealerships Inc.	6	McGill University	4
University of Saskatchewan	15	Sociedad Quimica y Minera de Chile SA	8	FluroTech Ltd	6	Iteris, Inc.	4

Table 2. *Cont.*

Entity	Freq.	Entity	Freq.	Entity	Freq.	Entity	Freq.
PreveCeutical Medical Inc.	13	Toronto-Dominion Bank	8	WeedMD Inc.	6	Ontario Ministry of Agriculture, Food and Rural Affairs	4
Natural Sciences and Engineering Research Council of Canada	13	Thompsons Limited	8	American Vanguard Corporation	5	Itafos	4

Table developed by the authors 2020.

Subsequently, the stakeholder inclusion framework presented above was applied to all stakeholders, labelling each stakeholder with the appropriate category. In a final step, for each stakeholder group the number of stakeholders in the data set, as well as the frequency of their mentions, were added up and included in the brackets in Table 1. For example, the agricultural equipment stakeholder group—Ag Equipment (12/98)—comprised 12 companies in the data set, which were mentioned a total of 98 times in the ten years in the news articles that digital agriculture covered.

It is important to note that the media analysis method is only designed to identify organisational stakeholders, and as such the columns representing individuals are not captured.

4.3. Application of the Framework

As evident from the numbers in Table 1, the stakeholder inclusion framework presented encompasses all stakeholders identified through the media analysis. The framework serves to demonstrate that the media analysis captures the main stakeholder groups active in digital agriculture. It also highlights that not all smaller stakeholders are captured. This finding is aligned with insights from the literature, namely that smaller stakeholders do not receive the same coverage as big commodity-crop firms [8].

The frequency with which each stakeholder group is mentioned in the media reinforces the finding that a small number of stakeholder categories are garnering the majority of media attention. Industry actors at the meso level are mentioned more often than others, and within this group, the directly involved companies are more frequently mentioned than other groups. Some societal actors are mentioned, however the only societal stakeholder group that received much media attention was at the macro level, and in particular government actors were mentioned frequently. Thus, both from the perspective of number of actors mentioned and the analysis of their share of the media space on digital agriculture, it becomes clear that there is a bias in the public discourse towards the industry and meso level.

In addition to supporting academic analyses, the framework also enables practitioners interested in addressing such biases to identify groups that should be included to achieve comprehensive representation. This might be of interest, for example, to journalists aiming to cover the field of digital agriculture comprehensively, or to government or other bodies conducting consultations.

Applying the framework in the context of building a representative sample or identifying participants for consultation processes would involve mapping selected respondents onto the framework and then systematically aiming to identify respondents from the missing categories.

5. Conclusions

This study offers a systematic framework for stakeholder identification and categorisation in the context of a digital agriculture ecosystem. In our proposed model, based on the structure, stakeholders are grouped into individual, industrial and societal stakeholders.

Then, these groups are plotted against of the micro, meso and macro levels of impact or power in the agri-food system. Within each category of the framework, stakeholders are grouped in a thematic manner. Such a categorisation can facilitate including new stakeholders based on their characteristics. To demonstrate the application of this framework, we provided an analysis of Canadian print media, identifying relevant stakeholders and placing them within the framework.

Recent scholarship has argued for the necessity of developing a more comprehensive and systematic approach for responsible innovation in digital agricultural [5,29,30]. Compared to the current methods applying snowballing approaches where the interviewed stakeholder introduced other stakeholders, the prosed framework may be less prone to bias.

The framework can be applied both in academic research, for example, to ensure systematic representation and inclusivity in empirical research, as well as in practical contexts including government policy and program consultations, the development of sector initiatives such as living labs, and inclusive innovation and commercialisation efforts.

Future work could enhance the framework further by including the structure of the entire agri-food sector or devising a stakeholder map that captures the engaged stakeholder groups across the industry's supply chain, value chain and the integration of broader ecosystem-level stakeholders. Future work could also test this model against other jurisdictions.

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6. Conclusion

This thesis studies the relationship between digital transformation and stakeholders in the context of ecosystems. As discussed in the introduction, to understand the impact of digital technologies, we need to understand the impact on the stakeholders and their expectations of value. Also, understanding the impact of digital technologies on stakeholders requires addressing these technologies in the ecosystem context. Comparing the findings of the four studies points to a specific aspect of the relationship between digital transformation and stakeholders in the ecosystem that is not currently discussed in the literature. The findings demonstrate a dynamic relationship between digital transformation and stakeholders in the ecosystem. This dynamic relationship shows the implications of two levels of digital technologies on stakeholders tend to change in different directions when moving from micro to meso and macro-level analysis.

6.1. Synthesis of the findings

The impact of digitalisation technologies at the macro-level tends to be positive on overall ecosystem value delivery to diversified stakeholder groups. As explained in the next section, the analysis shows the contribution of digitalisation technologies in developing concepts that accommodate broader stakeholder inclusion. This finding is in line with the arguments for the positive impact of digital transformation on the overall well-being of the society (Fritsch et al., 2008; Brynjolfsson & McAfee, 2013; Jha et al., 2016; Fromhold-Eisebith, 2017; Linkov et al., 2018; Täuscher & Abdelkafi, 2018; Jovanović et al., 2018). However, the research community, including academia and policy researchers and activists from the public and private sector, needs to be cautious when inferring this facet of digitalisation to lower levels of analysis, particularly the micro-level. The analysis shows that the positive impact at the macro-level (entrepreneurial ecosystem) is not readily transferable to improve the value perceived by individual stakeholders.

In contrast to digitalisation, digitisation technologies conceptually cannot lead to major changes in the macro-level of society as they are mainly applied to enhance internal efficiencies of value delivery models (Matt et al., 2015; Legner et al., 2017). Hence, they have a limited impact on the value perceived by stakeholders at the macro-level. In addition to their technical capabilities, this difference in impact on stakeholders is also amplified by how societal objectives are set. As discussed in the second chapter, there is a tendency to set general societal value objectives at the top level of society.

Digitalisation technologies correspond to the expectations of societal value objectives at the macro level as they can deliver overall value to society (Matt et al., 2015; Fromhold-Eisebith, 2017; Jovanović et al., 2018; Linkov et al., 2018). The third study confirms that concepts based on the digitalisation foundation could promote greater stakeholder inclusion in the ecosystem compared to those based on the digitisation foundation. Therefore, digitalisation technologies can be used to set general objectives such as enhancement in food production or improved health and education delivery. Yet, as noticed with the tendency of setting general social objectives in chapter two, macro-level goals and objectives are hard to operationalise at the micro-level. Hence, as observed in chapter one, the positive impact of digitalisation remains limited at the micro-level analysis. The change in the impact of digitisation and digitalisation on stakeholders based on three levels of analysis is explained in the next section.

6.2. Transformation of the impact of digital technologies in the ecosystem:

Within the scope of the covered studies, the findings suggest that in the context of the ecosystem, the impact of digital technologies has different implications as the level of technologies evolves from digitisation to digitalisation. The impact of digitisation, to an extent, can be positive at the micro-level of analysis and with respect to individual stakeholders in areas like inclusion in the enterprise operations. However, this positive relationship may fade at the higher level, such as at the meso level of enterprise communication, and at the macro-level analysis of the ecosystem inclusion. Contrarily, the impact of digitalisation tends to be positive at the macro-level of analysis and with respect to the inclusion of diversified stakeholders in the ecosystem. This positive impact is persistent at the meso level in terms of the positive impact on communication of digitalisation on the communication of social value. However, the positive impact could not be inferred at the micro-level of analysis in the context of creating a conducive ecosystem for integrating women into higher decision-making roles of digital start-ups. Therefore, the finding of this thesis can be synthesised to develop an insight into how the impact of digitisation and digitalisation transforms based on the level of technology and analysis. The findings show that the impact of digital transformation on stakeholders is not constant but is dynamic and transforms in two dimensions. First, when evolving from digitisation to digitalisation. Second, when evolving from the micro-level to meso-level and the macro of analysis in the ecosystem. In the following section, this impact is traced to enhance the insight.

- **Tracing the transformation of the digitisation impact on stakeholders**

  At the **micro-level** of individual analysis, there is evidence that digitisation may lead to neutralising gender differences at the operational level (Churchill & Craig, 2019; Roos et al., 2021; Vasilescu et al., 2020; Wiseman et al., 2018). This evidence appeared in the literature review of the first study at the individual level of women's inclusion in the workplace. Although, it can be argued that the gender-neutralising impact of digitisation may still reflect some aspects of inequalities in the ecosystem. Digitisation is concerned with automation at the operation level rather than managerial positions. Thus, such improvement still includes subtle gender-biased implications.

  At the **meso level** of enterprise analysis, the second chapter provided statistical evidence that increased communication of digitisation can lead to increased communication of one aspect of social value (stakeholder inclusion theme). This theme addressed individual stakeholders. Such an impact on increased communication of social inclusion conceptually could be explained through the rule of digitisation technologies in neutralising the gender differences in the workplace, as discussed in chapter one. However, the study did not control for technology implementation. Therefore, proving the causality needs further investigation.

  At the **macro-level**, the positive impact of digitisation is revered when the topic is discussed concerning the conceptual capacity for inclusion of societal stakeholders in the ecosystem. Concept analysis in the third chapter showed that technological concepts developed on a foundation of digitisation technologies might promote subtle exclusion of wider ecosystem stakeholder groups in favour of certain economic stakeholders interested in production and efficiency.

- **Tracing the transformation of the digitalisation impact on stakeholders**

  At the **micro-level** of individual analysis, the first study provided evidence of persisting inequalities in the context of the digital entrepreneurial ecosystem and start-ups engaged in developing digitalisation innovations. The analysis in chapter one showed two concerns with respect to the interest of individual stakeholders. First, the inclusion of women in the management teams is delayed, leading to depriving women of ownership benefits. Second, the inclusion of women in managerial roles is negatively associated with VC funds that put start-ups with a higher proportion of women in a disadvantageous position. Hence, digitalisation in the entrepreneurial ecosystem has not contributed to levelling the ground for women's inclusion in managerial roles. However, such an impact is arguably related to the biased systemic culture in the ecosystem rather than a direct impact of digitalisation. However, the cultural dimension is not investigated in the study.

At the **meso level** of analysis, the second chapter provided statistical evidence that communication of digitalisation technologies is positively associated with the communication on three themes of social value (stakeholders' engagement, stakeholder inclusion, and Ethics). As discussed in chapter two, such an impact on the communication of social value and social demands conceptually could be explained through the role of digitalisation technologies in changing the perception of the source of value and the argument of the dissolved enterprise boundaries. However, the study did not control for technology implementation. Therefore, proving causality needs further investigation.

At the **macro level,** digitalisation conceptually demonstrated a positive impact on stakeholder inclusion. The finding of concept analysis in the third chapter showed that concepts developed on the foundation of digitalisation technologies could conceptually accommodate the broader inclusion of societal stakeholder groups in the ecosystem.

6.3. Summary, contributions and implications of the chapters

This thesis studies four aspects of the relationship between digital technologies and stakeholders. In the first chapter, the relationship between digital technologies and women's inclusion in managerial roles is discussed. This study is concerned with individual stakeholders (micro-level). The study assesses the scope of women's inclusion in managerial roles in the digital start-up across three industrial sectors in North American and European countries. In the second chapter, the impact of digital technologies is discussed in terms of the impact of communication of digital technologies on the communication of stakeholders' value at the enterprise. This study is concerned with enterprise and organisational level stakeholders (meso-level). The study covered two levels of digital technologies and three themes of social value perceived by different stakeholder groups. In the third chapter, the impact of digital technologies is discussed in terms of the inclusion of societal stakeholders in the digital agriculture ecosystem. This study is concerned with societal stakeholders (macro-level). The study assessed the scope of stakeholder inclusion of the emerging concepts in the digital agriculture ecosystem. In the fourth chapter, the impact of digital technologies is discussed in terms of the necessity of developing a systematic framework for stakeholder identification that impact the agriculture ecosystem. This study is concerned with societal stakeholders (macro-level). This study proposed a systematic framework for stakeholder mapping at micro, meso, and macro levels of analysis. Additionally, it took into account different structures of stakeholder groups, including individual, enterprise, and societal stakeholders with direct and supportive roles in the ecosystem.

Contributions and implications of each chapter are explained in the following sections.

- **Digital technologies and individual stakeholders (women) in managerial roles in venture capital-funded digital start-ups**

  Based on recent corporate data analysis (start-ups incorporated between 2010 to 2020), the results suggest that it is unlikely that digital entrepreneurship has an extensive levelling effect on women in venture capital-funded digital start-ups. The analysis provides evidence that the previous findings of positive effects in specific digital areas like online advertising, crowed funding and media (Mallia & Windels, 2011; Johnson et al., 2018; Gafni et al., 2021) cannot be generalised to expect a levelling impact in managerial roles. Thus, the analysis provides updated results to conclude that the recent digital transformation in the entrepreneurial ecosystem has not positively impacted women's inclusion in managerial roles in general. Instead, the analysis provides updated evidence to support the argument that the funding amounts remain associated with gender in the digital ecosystem (Coleman & Robb, 2009; Robb & Watson, 2012; Guzman & Kacperczyk, 2019). Additionally, the analysis of changes over time reveals a dimension of the gender gap that is rarely addressed: digital start-ups tend to integrate women into the leadership team only after the first two years. This result suggests women are rarely involved in the early start-up activities, which typically reward founders and executives who join early with ownership shares. This study has important implications for current public and policy discussions on gender in digital entrepreneurship. It shows that the concerns raised about the gendered workplace culture in Silicon Valley may be more broadly relevant, that the software and digital fields, in general, have low participation of women, that women entrepreneurs are not granted the same resources as male entrepreneurs, and that women are likely to benefit less from their involvement in digital start-ups as they tend to join after the founding stages.

- **Digital technologies and enterprise-level communication of societal value in the ecosystem:**

  The analysis of communication of digitalisation technologies expressed on social media showed that they are positively related to the communication of the three themes of social value, including engaging with stakeholders, social inclusion, and ethics. The literature posits that as a result of digitalisation, the enterprise boundaries begin to dissolve, and the external environment can contribute to value creation. Thus, the enterprise becomes sensitive to the external environment (Gray et al., 2013; W. Li et al., 2012; Woerner & Wixom, 2015; Matt et al., 2015; Stock & Seliger, 2016; Legner et al., 2017; Nambisan, 2017; L. Li et al., 2018; Pinzone et al., 2018; Manda & Ben Dhaou, 2019). The analysis confirms that communication of digitalisation technologies is associated with stakeholder value reflection in enterprise communication. Additionally, the analysis shows a positive contribution of digitisation technologies (concerned with automation and internal efficacies) to social inclusion communication. This finding is particularly interesting considering the theoretical argument that digitisation had a limited impact on interacting with the external environment (Legner et al., 2017). This finding implies the positive impact of digitisation communication on improving the communication of inclusion at the enterprise level. Conceptually, this finding can be explained through the argument that digital transformation in the workplace can improve individual-level inclusion (Churchill & Craig, 2019; Roos et al., 2021; Vasilescu et al., 2020; Wiseman et al., 2018). However, confirming this explanation requires analysis beyond the applied method. The study has two implications from managerial practice and policy perspectives. First, developing strategies for implementing and utilising digitalisation technologies can provide a method for the data collection on diversified stakeholders' demands, including the demand for social value. Second, from a policy perspective, promoting conversations of digitisation and digitalisation initiatives can positively impact the perception and communication of social value in the ecosystem.

- **The impact of emerging digitally-enabled concepts on conceptualising stakeholder inclusion in the ecosystem**

  The analysis of concepts applied to digital agriculture shows they have conceptually different scopes and implications on stakeholder inclusion in agricultural innovation systems. The analysis is conducted based on the assessment of the underpinning technological foundation (digitisation versus digitalisation) of each technological theme applied in digital agriculture. The analysis reveals that digitisation-based concepts such as big data in agriculture (when related to production), precision agriculture, precision farming, satellite farming, and site-specific crop management are mainly concerned with farm-level management. The impact of this group of technological concepts is mainly discussed in the context of efficiency and productivity at the farm level, with implications for stakeholders with economic interests (Phillips et al., 2019; Carolan, 2017b; Bronson, 2018; Bendre et al., 2015; Fielke et al., 2019). Therefore, themes developed on this foundation have limited interaction with non-economic stakeholders, consequently limited implications for broader stakeholder inclusion in the ecosystem. Hence, conceptually these concepts can promote subtle exclusions in the ecosystem. On the other hand, the analysis shows that digitalisation-based concepts such as digital farming, e-agriculture, farm 4.0 and agriculture 4.0, digital agriculture, smart farming, and smart agriculture have implications that exceed the farm-level and extend to ecosystem-level implications. The impact of this group of technological concepts includes challenges and opportunities for multiple stakeholder groups in the ecosystem (Carolan, 2020; Wolfert et al., 2014; Wolfert et al., 2017; Regan, 2019; Higgins & Bryant, 2020; Klerkx et al., 2019; Rose & Chilvers, 2018). Hence, these concepts conceptually can promote a broader stakeholder inclusion in the ecosystem. Among the digitalisation-based concepts, the analysis distinguishes between agriculture 4.0, farming 4.0, e-agriculture, and digital farming that have platform-level (Carolan, 2020) or local-level of implications (Raj, 2013; Rashid, 2014) and the concepts of smart farming, smart agriculture, and digital agriculture. The latten concepts have a more comprehensive scope for including a broader variety of stakeholders. The study has implications for the development of the discussions and conceptualisation of ethical decision making in the digital agricultural transition. The study calls for applying concepts that move beyond technical or economic issues and allow us to envision a broader set of societal concerns and stakeholder needs in the ecosystem.

- **A systematic stakeholder inclusion framework in the digital agriculture ecosystem**

  Based on news article analysis and the Responsible Research and Innovation (RRI) literature, the study offers a systematic framework for stakeholder identification and categorisation in the context of a digital agriculture ecosystem. Scholars such as Eastwood et al., (2017) highlight the necessity of including all stakeholder groups to maintain a responsible innovation process in the ecosystem. The study responds to the necessity of developing a comprehensive and systematic approach for stakeholder inclusion in the context of responsible innovation in digital agriculture (Rose & Chilvers, 2018; Bronson, 2019; Phillips et al., 2019). For adaptability purposes, the proposed framework has taken into account the current approaches to stakeholder analysis in the field, including the three-level hierarchical approach of the micro (individual), meso (institutional) and macro (socio-political and macroeconomic) levels of analysis (Kuzma & Roberts, 2018; Aksoy et al., 2019), and the thematic approach which is based on heterogeneous assemblage (Andrieu et al., 2019; Regan, 2019; Carolan, 2018; Fielke et al., 2019). In the proposed model, stakeholders are grouped into individual, industrial and societal stakeholders based on their structure. The model also distinguishes stakeholders with direct engagement in digital agriculture and those with supportive roles. Then, these groups are plotted against the micro, meso and macro levels of impact (their respective power in the agri-food system). Stakeholders are grouped thematically within each category of the framework (e.g., Agriculture Equipment). Compared to the current methods of applying snowballing in stakeholder identification, where the identified stakeholders introduce other stakeholders (Andrieu et al., 2019; Carolan, 2017a; Carolan, 2020; Fielke et al., 2019; Higgins & Bryant, 2020; Klerkx et al., 2019) the proposed framework may be less prone to bias and complements the current practice. The study has two implications for academic research and application to practical contexts. The framework can be applied in academic research, for example, to ensure systematic representation and inclusivity in empirical research. Also, it can be applied in practical contexts, including government policy and program consultations, the development of sector initiatives such as living labs, and inclusive innovation and commercialisation efforts.

6.4. Limitations of the chapters methodology

The studies have limitations in the applied methodology and inferring the findings. Addressing these limits requires further research and different methods.

First study: The analysis was designed based on gender analysis. The focal variable in this study, gender, was not available in the database and had to be derived based on given names. The gender is extracted using an R package that uses a subset of the US Census data. While this package delivers excellent results for names that are common in the United States, gender identification performs less well for uncommon names, which may introduce a bias in terms of professionals not born in North America. A further limitation is the definition of industries in the applied database, which are not very detailed and may, in some cases, group digital and more traditional start-ups. For this study, a range of different definitions and groupings to ensure the robustness of the inclusion criteria is explored. In addition, data on the education of individuals is not consistently available.

Second study: The analysis was designed based on the communication of certain keywords on social media. Although the keywords were carefully selected based on how the digital and social concepts were measured in literature, this approach may need a more robust method to analyse the impact in practice. Conceptually, the findings cannot suggest that higher communication of the detected social themes in this study means improved social value delivery in practice. Examining the assumption of whether improved communication of social value on social media platforms can be translated as improved social value delivery in practice requires different data collection methods. Similarly, the findings do not suggest that communication of a certain level of technologies (for example, digitalisation) is associated with the implementation of the related technologies at the enterprise level. Although the literature conceptually explains the impact of digital technologies in interacting with external stakeholders (Gray et al., 2013; Stock & Seliger, 2016; W. Li et al., 2012), the study did not control for technology implementation. Hence, the causality of the impact cannot be firmly concluded. Also, with respect to the argument of the dissolve boundaries of the enterprise and the change in the perception of the source of value, other relevant theories such as open innovation can be applied to explain the observation.

Third study: The analysis was designed based on the underpinning digital technologies of concepts concerning digital transformation in agriculture. The discussion is conducted at a conceptual level through literature analysis without assessing the practical dimension. The study can benefit from outlining the obstacles faced within each theme that challenges adopting an ecosystem approach. The obstacles can be outlined by collecting and analysing primary data or conducting analysis on secondary sources.

Fourth study: The analysis was designed to identify stakeholders based on news article analysis. However, media tend to cover news related to more prominent stakeholders in the field, whereas the role and interests of less prominent groups may not receive the same coverage. The identified stakeholders were complemented by stakeholders covered in the literature. However, some relevant stakeholders might be neglected, particularly at the micro-level analysis. Also, in the dynamic context of the ecosystem, stakeholders may adopt different roles across the industry's value chain. The proposed framework does not capture the translation of value.

6.5. Emerging gaps and future research directions

The analysis in this thesis is conducted based on three levels. This approach prepared the ground for systematically identifying gaps and investigating further dimensions at each level of the analysis for future research.

At the **micro-level**, further studies are needed to understand the impact of the established norms of practice in the entrepreneurial ecosystem that can impact the benefits of digital transformation. The literature discusses the evidence that digital technologies are capable of improving the particle in some areas concerning individuals (Mallia & Windels, 2011; Johnson et al., 2018; Gafni et al., 2021). However, the analysis demonstrates that systemic inequalities could persist and not disappear when transfigured through digital technologies. Another opportunity for future research at the micro-level is to investigate the effect of digital technologies on empowering individual stakeholders in the context of the ecosystem. The literature highlights the empowering mechanisms of digital technologies, like the educative and communicative impact, on empowering individuals (Azeiteiro et al., 2015; Fromhold-Eisebith, 2017; Ye et al., 2020). Digital technologies can empower individuals to demand socially accepted values but also can be tainted by certain stakeholder groups for detrimental purposes. The empowering mechanisms of individuals need further development as new online platforms such as Metaverse are emerging.

At the **meso-level**, further investigation is needed to understand whether implementation of a higher level of digital technologies in practice can lead to improved social value delivery performance at the enterprise level. The literature theorises the possibility of such causality (Imgrund et al., 2018; Legner et al., 2017; Matt et al., 2015; Gray et al., 2013; Stock & Seliger, 2016). The possibility can be conceptually explained through the argument of dissolved boundaries and change in the source of value (Matt et al., 2015; Woerner & Wixom, 2015; Nambisan, 2017; L. Li et al., 2018; Gray et al., 2013; Stock & Seliger, 2016; Legner et al., 2017; W. Li et al., 2012; Pinzone et al., 2018; Manda & Ben Dhaou, 2019). Additionally, the analysis shows a positive association between digital technologies communication and enterprise communication of social value. However, confirming this possibility requires further research, and the causality needs to be tested in practice. Another research opportunity is investigating the impact of digital theologies in setting shared values with society. The literature theorises such a possibility between the enterprise and society (Porter & Kramer, 2011). The literature also regards the positive impact of digital technologies as the backbone of building constructive relations with societal stakeholders (Fromhold-Eisebith, 2017). However, the mechanism of such an impact needs further clarification and operationalisation at the enterprise level.

At the **macro level,** further investigation is needed to understand how digital technologies are applied in the dynamic environment of the ecosystem to influence other stakeholders. At the conceptual level, the analysis demonstrates the impact of digital technologies extends to include a diversified stakeholder in the ecosystem. However, in a dynamic environment, stakeholders may leverage the advantages of digital technologies to gain more power, often to the detriment of smaller stakeholders. The literature highlights growing concerns that power asymmetries can benefit the already-powerful stakeholders, such as giant Agri-tech companies (Nally, 2016; Bronson, 2018; Higgins et al., 2017). On the other hand, such an asymmetric power gain can cause more inequalities against the interest of vulnerable and marginalised stakeholder groups, like smaller farms and businesses in the ecosystem. Thus, further research is needed on the impact of power delivery of digital technologies in areas like how digital power is exerted by stakeholders, how digital power is aggregated among certain stakeholders, and how to alleviate the disadvantageous impact of digital power. Another research opportunity is investigating the impact of barriers on adopting an ecosystem approach within digital transformation. Scholars call for taking an ecosystem approach when addressing digital transformation issues in areas like digital agriculture to ensure stakeholder inclusion (Eastwood et al., 2017). However, stakeholder inclusion in the ecosystem context may face several barriers in practice. The barriers can include various obstacles such as technical barriers to adopting advanced technologies, access to the required knowledge and expertise, skill development and training, or inadequate interaction and networking with other stakeholders due to power asymmetries. These barriers need further research and solutions development for the equitable benefit of the entire ecosystem.

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