Digitalization in the agri-food industry: *A systematic literature review*

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Abstract

A transition in the agricultural sector is going on, researchers are already talking about ‘a digital agriculture’. However, agri-food firms are facing challenges in adopting digitalization in their businesses. This paper investigates what challenges agri-food firm face in adopting digitalization. A systematic literature review was conducted in order to investigate those facing challenges. In total 21 out of 508 articles were used. The analysis of these articles has resulted in three types of challenges, namely: challenges related to the implementation of digitalization, the usage of digitalization, and as a consequence of digitalization. Subsequently, barriers were found regarding the challenges and eventually linked to each type of challenge. Based on these results, the challenges are mostly present within the implementation of digitalization which were supported by eleven barriers of which access was an important barrier. Subsequently, the usage of digitalization was supported by seven barriers of which data complexity seemed to be most important. Lastly, four consequences were found as challenges of digitalization, these were mostly focussed on the management and policy levels. Further research is suggested to extend the facing challenges of agri-food firms.

Keywords: Digitalization, agri-food firm, challenges, barriers

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Introduction

Nowadays, companies are increasingly making use of digital technologies which has resulted in a new phenomenon where researchers frequently talk about. This phenomenon is called: Industry 4.0. According to Zezulka, Marcon, Vesely, & Sajdl (2016) this 'Industry 4.0' is used for three interconnected factors, namely: digitalization and integration of simple technical - economical relation to complex technical – economical complex networks, digitalization of products and services offer, and lastly new market models.

Even in the agricultural sector researchers are already talking about 'Agri-food 4.0' (Miranda, Ponce, Molina, & Wright, 2019) and 'a digital agriculture', the latter is defined by Shepherd, Turner, Small and Wheeler (2018) as "the use of detailed digital information to guide decisions along the agricultural value" and can take place in the whole value chain. This detailed digital information is often called 'big data' and is used and developed by technologies such as the 'Internet of Things' and 'cloud computing' (Wolfert, Ge, Verdouw, & Bogaardt, 2017).

For the food industry, adopting robots in the production line and making use of automations are very attractive, because they can lower the production costs. Especially for an industry like the food industry which has a large competitive environment and where labour costs abroad are significant lower, this adoption will be necessary according to Masey, Gray, Dodd, & Caldwell (2010). This is also supported by Sundmaeker, Verdouw, Wolfert, & Pérez Freire (2016) as they state that adopting the Internet of Things in a business process, will result in intensely improvements in productivity and sustainability. However, despite the fact that those researchers state that digitalization can improve companies' processes, there are still farms that cope with challenges in adopting digitalization.

This paper will focus on the digitalization of the agriculture and tries to investigate what challenges agri-food firm face in adopting digitalization by doing a systematic literature research. In terms of relevance, digitalization is a nowadays process which creates good opportunities for companies. By not making use of the new technologies while other firms do, a consequence can be that firms are getting behind in their large competitive environment (Rao, 2003). From a learning perspective for companies, this paper tries to help businesses with learning from other farmers' experiences, because learning from organizational experiences, in this case experiences in challenges as well as those from other firms, helps in understanding business process re-engineering for your own firm (Jarrar & Aspinwall, 2002). This research tries to contribute by giving insight into the challenges that agri-food firms face and will provide knowledge for researchers and decision makers which will eventually help them with making well-considered decisions about adopting e.g. big data or automatizations in business processes.

Within the confines of digitalization in the agri-food sector, various researchers like Rotz, Pannell, Duncan, Weersink, & Fraser (2018) and Coble, Mishra, Ferrell, & Griffin, (2018) have done research into different kind of challenges in the agri-food sector. Rotz et al. (2018) were focussing on the technical and organizational challenges of digitalization in the agri-food

industry with a scope on the natural environment, while Coble et al. (2018) were more focussed on the challenges of digitalization for researchers and firms that are ahead. Other researchers like Zambon, Cecchini, Egidi, Saporito, & Colantoni (2019) are concerned about the fast growing industry in general compared with the adopting speed of the newest technologies in the agriculture, because 'Industry 5.0' is starting to grow while the agricultural sector still has difficulties in adopting the technologies of 'Industry 4.0'.

So, based on these earlier research studies, there are concerns about the adoption speed of digital technologies within the agriculture and a lack of a clear overview about the problems that agri-food firms face in adopting digitalization within their businesses. Moreover, there is also a relevant research gap that needs to be investigated and which will be essential for decision makers in this area.

This essential research gap will be investigated with the question: 'what challenges do agri-food firm face by adopting digitalization?'. In order to answer this question, a literature review will take place by following the steps of Tranfield, Denyer, & Smart (2003). In the next section, the methodology, I will present how this systematic literature review has taken place. Subsequently, in the results section, a descriptive analysis will take place and I will scope out the theoretical field. After that, a synthesis section will follow, and the paper will end with a discussion based on this research.

Methodology

In order to collect data about the challenges related to digitalization in the agri-food industry, a literature study has to be done. An often-used method for reviewing the literature is based upon only three steps: data collection, data analysis and data synthesis. However, to extend this method in order to improve the quality of the review process and to provide a transparent and reproducible procedure, I made use of a more systematic review approach which is described by Tranfield, Denyer and Smart (2003). This approach consists of ten phases divided over three stages, namely: planning the review, conducting a review and reporting and dissemination. In this section, the first seven phases will be discussed and phase 8 'data synthesis' will be presented in a descriptive manner in the section 'Results'. The last two phases consist of making a conclusion, discussion and recommendations which will return in the section 'Discussion'.

Stage I - Planning the review

During the first stage it is necessary to identify the need for a review, which is subsequently followed by the preparation of a proposal for a review and finally ends with a development of a review protocol (Tranfield et al., 2003). Those steps have already taken place and are already elaborately explained and discussed in the introduction section. Next to that, I had to identify a key data source that will be used for collecting appropriate data. The key data source that was used is the online database 'Scopus', because this is the largest database of peer-reviewed literature. When Scopus did not give access to specific articles, then Google Scholar was used as a backup database. Moreover, there was only searched for academic articles and reviews

which are peer reviewed, because peer-reviewed articles and reviews are in general more reliable as those are evaluated by a panel of professionals in that field.

Stage II – Conducting a review

The second stage 'conducting a review' consists of the five following steps: identification of research, selection of studies, study quality assessment, data extraction and monitoring progress, and lastly data synthesis (Tranfield et al., 2003). These followed steps will be individually clarified.

Identification of research

As mentioned earlier, the process of gathering data took place in the online database of 'Scopus'. However, keywords and search term criteria had to be defined to collect the peer reviewed articles. The search terms which were used, and which were allowed to be present in the article title, abstract and key words are: 'agri-food', 'agriculture', 'farm*', 'smart farm*', 'digit*', 'big data', 'artificial intelligence', 'AI'. These search criteria delivered 13173 documents which were subsequently filtered by only articles and reviews as document type, because books and conference papers are often not peer reviewed and requires additionally too much time to analyse for this study. Besides, articles in 'social sciences' as subject area were included, because this research is linked to this area. Lastly, only journals as source type were used with the same reason given by 'document type' and the language had to be English as I cannot speak and read Chinese, Italian, Portuguese and Spanish. This resulted in 566 articles which could subsequently be selected, analysed and used.

The search terms were linked and used as the following query string will show:
TITLE-ABS-KEY((("agri-food" OR agriculture OR farm) AND ("smart farm*" OR digit* OR "big data" OR "artificial intelligence" OR AI))) AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"re")) AND (LIMIT-TO (SUBJAREA,"SOCI")) AND (LIMIT-TO (LANGUAGE,"English")) AND (LIMIT-TO (SRCTYPE,"j"))*

Selection of studies and study quality assessment

In order to process data, the 566 articles were categorized first. The categorization is based on reviews only as the first group. Subsequently, the second group is based on highly cited papers. Categorizing on highly cited papers can give biases, because recent papers do not have enough time to be cited (Crossan & Apaydin, 2010). To ensure that this bias will not exist, the third group consists of recent papers (2009-2019). In total, these groups gave together 508 articles, because papers which were older than ten years and not highly cited were eventually excluded. After this categorization, all articles were screened on the quality of the journal in which they were published. This screening is based on the academic journal guide 2018 and only articles in journals which are classified as 2, 3, 4 or 4* were selected. As first, journals with a classification of lower than 3 were excluded, however, this gave too few results which resulted in including classified journals of 2 as well. Lastly, the articles were also limited in each group on relevance by checking if the articles are linked to the agri-food sector by reading the titles and abstract.

Table 1 shows in recap how the articles were selected and analysed. As a result of the analysis, twenty-one articles will be used.

Group	Initial pool	Screening	Abstract analysed	Less duplicates
Group 1 – Reviews	28	3	0	0
Group 2 – Highly cited papers	47	5	3	3
Group 3 – Recent papers	433	31	20	18
Total	**508**	**39**	**23**	**21**

Table 1: Selection of articles

Group 1: Reviews

To exclude all papers other than reviews, the search criteria in Scopus were limited on reviews only. This resulted in 28 review articles. However, after screening on quality of the journals in which the articles were published, this amount went to three articles after including classified 2 journals as well. But, when those three articles were analysed on their relevance for our research question by reading the abstract, introduction and conclusion, I decided to exclude those three reviews, because they were not giving answer on the research question and I was looking for empirical data.

Group 2: Highly cited papers

According to Saha, Saint and Christakis (2003), frequently cited journals are an indicator for articles that are of great interest in a specific field as those contains in general notable scientific advances. To define the term 'highly cited papers', I decided to include only articles that are cited at a minimum of five times per year. This resulted in five articles which were published in classified journals with a ranking of 2 or higher. After screening the abstract, introduction and conclusion of those articles, there were two articles which were not linked to challenges and digitalization. This resulted in eventually three relevant articles to use in the literature review.

Group 3: Recent papers

In this group articles are selected on their year of publication in order to prevent the bias that can occur by the two other groups. To describe 'recent papers' I decided to define these as papers that are published in the last ten years. So, papers that were published in the years 2009 up to and including 2019 are selected and analysed. This has led to 31 articles that were published in classified journals with a ranking of 2 or higher. However, after reading screening those articles on their relevance in answering the research question, the number of relevant articles went to 20. But, since two articles are already included in the 'highly cited paper'-group, I had to exclude those.

Data extraction and monitoring progress

Since human errors and biases can occur while doing research, there are methods to reduce this. One of these methods is making use of data extraction forms. These forms should consist of a documentation of details of the information source, features of the research and links to other concepts, identification of emergent themes and key results (Tranfield et al., 2003). In this research, the following data extraction form (Table 2) was used and processed in the computer program 'Excel':

Number	
Authors	
Year of publication	
Title	
Journal	
Volume	
Pages	
Document type	
Citation count	
ISSN	
AJQ 2018	
Region	
Research aim	
Research product	
Research method	
Challenges for who	
Challenges with background information	
Challenges related to	
Contribution	
Context from the abstract	
Answer on the research question	

Table 2: Data extraction form

Results

This section will be split into two parts, a descriptive analysis and a part in which I will scope out the theoretical field. The descriptive analysis part is a rough-cut and detailed analysis of the field in which the data will be extracted of the prior used data extraction forms (Tranfield et al., 2003). In this part I will also review the different types of challenges. Besides, an analysis of the theoretical content will be proceeded to understand how those challenges are interconnected to each other.

Descriptive analysis

From the data obtained from the twenty-one data extraction forms, there are some interesting findings. First of all, the oldest article that is included in this literature review is from 2003. This article is at the same time also the only article that did not need to be excluded from the recent papers' category. Next to that, it seems that during the years more relevant articles are published. Especially 2017 and 2018 cover almost 43% of all included papers, see Figure 1.

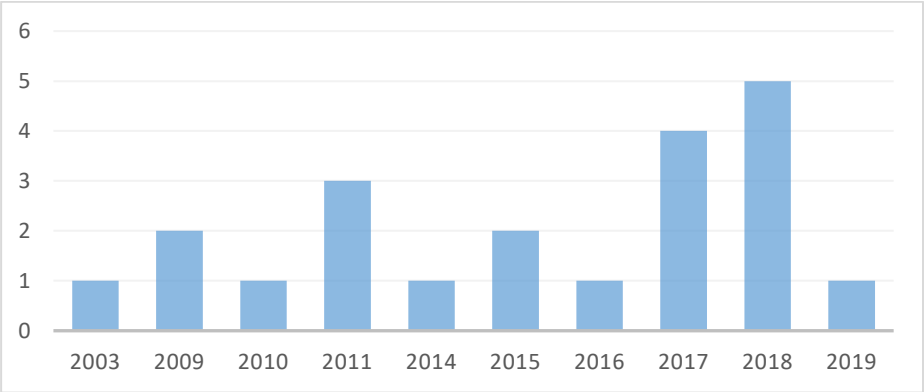

Figure 1: Breakdown of articles by publication year

After dividing the articles to its research method, the results in Figure 2 are showing that most articles were focussed on case studies (33%) and studies which were making use of surveys (29%). Other articles were making use of more mixed research methods by doing for example a literature research together with a case study or by doing a case study with field work, a document research and observation (5%).

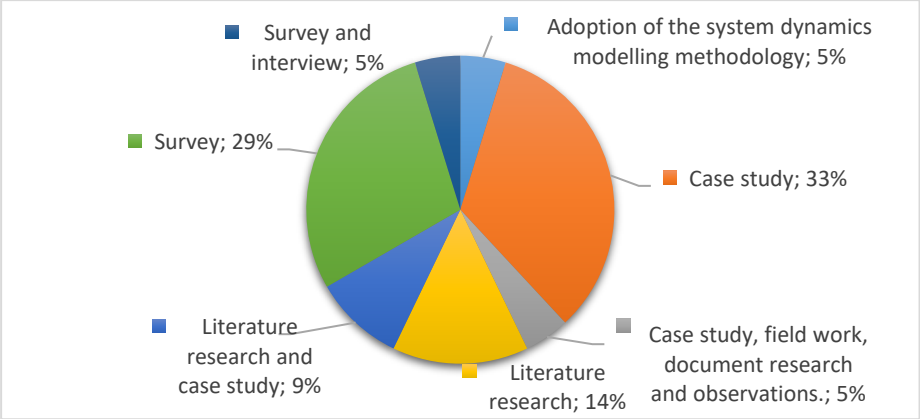

Figure 2: Breakdown of articles by research method

The breakdown of articles by region (Figure 3) shows that almost every paper is focussed on another region. This will result in a broad knowledge contribution since every situation is unique and divided over the world. Only 4 articles could not be linked to a specific country or region as those were not specified on a country but more on for example big data analysis within businesses in general. The only country that has more than one case study is Canada.

Besides, I was linking the regions to its continents and excluded the unspecified articles to visualize better how the articles are divided over the world. Despite the fact that almost every paper is linked to another region, Figure 4 shows that the continents North America (24%), Africa (23%), and Asia (23%) contains most of the articles. Europe, South America, and Australia are less represented in this literature review with in total 30% of the articles.

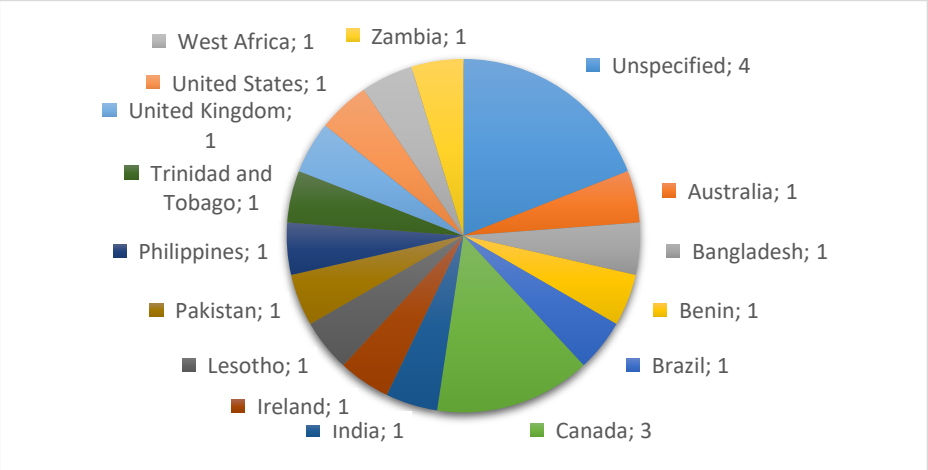

Figure 3: Breakdown of articles by region

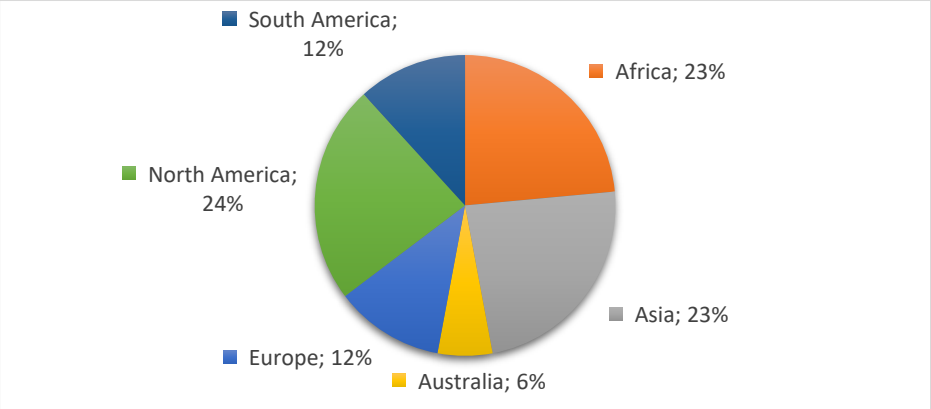

Figure 4: Breakdown of articles by continent (excluded the unspecified ones)

Rotz et al. (2018) indicated different challenges in the agriculture which were overall mostly focussed on the adoption of big data. However, I identified all challenges provided in the articles and found three core categories and two mixed categories (Figure 5). Those challenges are related to: the implementation of digitalization (34%), secondly, the usage of digitalization (33%), thirdly, the consequences of digitalization (14%), fourthly, the implementation and usage of digitalization (14%), and lastly, the usage and consequence of digitalization (5%). To better understand these categories an explanation will follow.

The challenges linked to the implementation of digitalization are all about the barriers that farmers and firms face in order to adopt digitalization within their company. Those barriers can be related to the lack of broadband in the agriculture or too high costs in order to adopt big data.

Secondly, the challenges linked to the usage of digitalization are all about the barriers that people face in the use of digitalization. For instance, internet access is not a problem and the digitalization is already present in farms, however, people do not know how to work with these technologies within a company due to its complexity.

Thirdly, the challenges that are related to the consequences of digitalization are about the challenges that decision makers or farmers face as a consequence of the presence of digitalization. An example of this can be how farmers have to deal with the risk framing within the media, another example can be that the farm cannot manage the increasing data as a consequence of big data usage.

The last two categories are a mixture of two of the above-mentioned core categories. The articles within these categories will present challenges which are related to these categories. An example of the implementation and usage of digitalization is the article of Mulauzi and Albright (2008) in which they discuss the barriers in access and usage of adopting information and communication technologies.

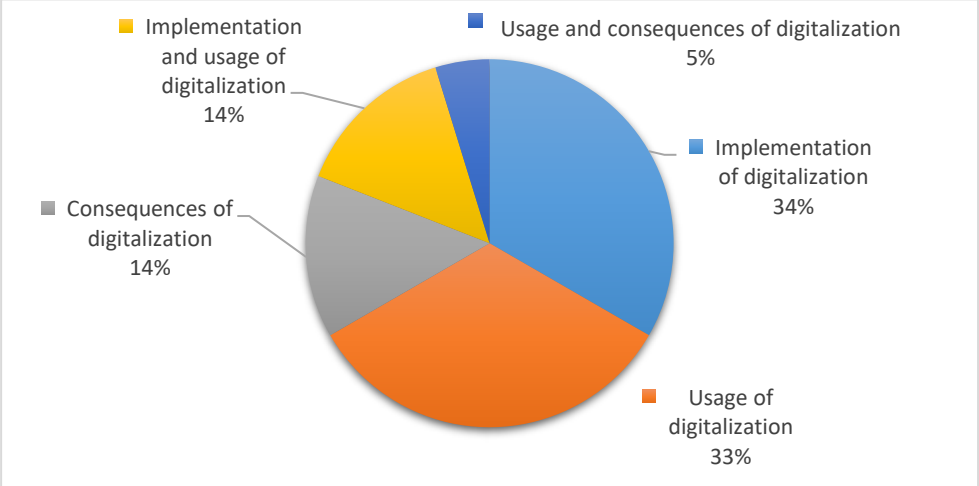

Figure 5: Breakdown of articles by kind of challenges

After the categorization, I was investigating where those challenges take place within the agricultural supply chain. This is represented in Figure 6. Overall, most of the challenges take place within the farm, which can be split up in small farms (9%), farms of professional women (5%), farms of grazier women (5%) and farms of which the size was not mentioned (43%). Some of the challenges are related to the whole agricultural value chain (5%) and in agricultural firms in general (14%), others are more linked to cooperatives, such as farmer groups (9%) and farms and commons (5%).

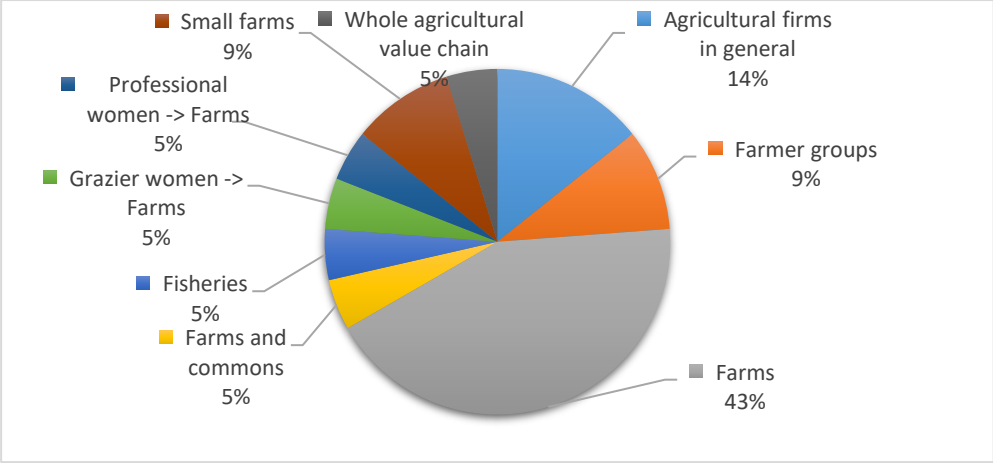

Figure 6: Breakdown of articles by focus in the value chain

Identifying each research product of the articles resulted in an enormous variety of research products as can be seen in Figure 7. However, there is one research product that appears in 19% of the papers. Digital divide seems to be an important aspect within this research area.

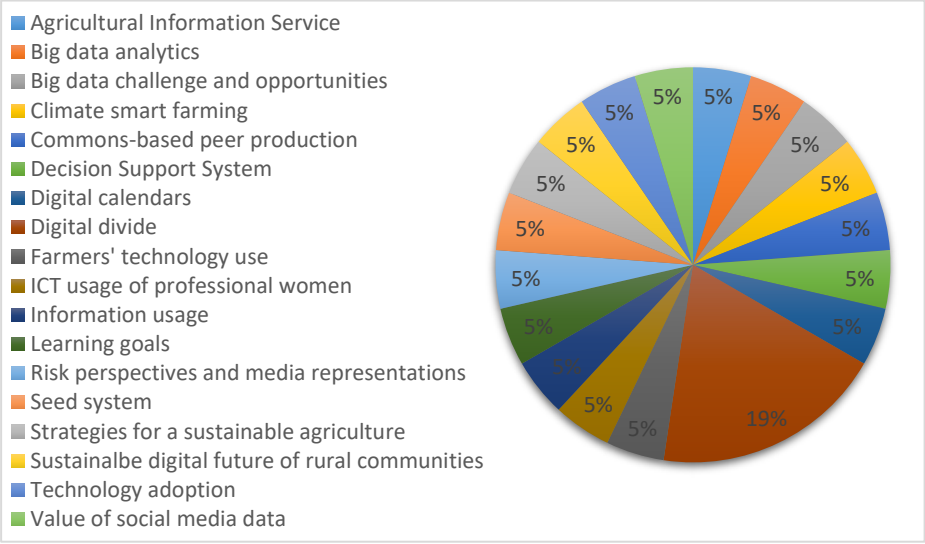

Figure 7: Breakdown of articles by research product

Scoping out the theoretical field

In order to understand how the faced challenges take place in the agricultural sector and to understand how those challenges are connected to each order, I was reviewing the theories about the challenges in my data extraction form. First, I organized the challenges by their presence in the agricultural value chain and linked them to their type of challenge. An overview of these findings can be found in Appendix 1. Subsequently, I was identifying which theories are connected to each type of challenge. This resulted in an overview of all possible theories that supports the type of challenges, this can be seen in Appendix 2 and Appendix 3.

Theories

Since I was excluding the review papers many of the analysed articles were purely empirical based studies. Moreover, almost every article was giving learning and knowledge management theories. Besides, despite the fact that I was linking the papers to its core category, many papers have supported other type of challenges as well (Appendix 3). Most articles were supporting the fact that, next to high costs and knowledge, access is a real barrier in the implementation of digitalization. For the challenges in the usage of digitalization, there is much support for the data complexity. Policy seems to be an important aspect in the challenges as a consequence of digitalization. Overall, most theories of the challenges were taking place within the farms itself and supported most of the time the challenges of implementation and usage of digitalization.

Type of challenges

I did not find any overarching framework that was in line with my framework that divided the challenges in three types (Figure 5). This can be caused by the fact that this systematic literature review did not include any reviews, so an absence of an overarching framework could have been foreseen. However, the empirical data from the data extraction forms showed that there were articles which included two different types of challenges.

Synthesis

This part will synthesis the obtained data in order to give an oversight of the currently existing challenges that agri-food firm face in adopting digitalization. This will be done by approaching each core type of challenge by its theory as showed in Appendix 3. First, the challenges which are linked to the implementation of digitalization will be discussed. This will be followed by the challenges in usage of digitalization and the challenges as a consequence of digitalization. Eventually the results will be concluded and discussed in the subsequently section.

The implementation of digitalization

As can be seen in Appendix 2, there are eleven causes that can hinder the implementation of digitalization in agri-food firms. These causes will individually be explained with support of case studies found in the articles.

Access

Access seems to be an important cause that hinder the implementation within farms according to its many references in articles (Appendix 2). Coble et al. (2018), who were focussing within their article on the agricultural value chain in its entirety, stated that the infrastructure works as a critical bridge between small and big data. When rural areas do not have access to this infrastructure, they will be disadvantaged since access to infrastructure then can be seen as a comparative advantage for firms that do have access to it.

This is also supported by Hay & Pearce (2014) as they found that access to technology has changed the farming lifestyle of rural women in Queensland, but also the farming practices since technology adoption results in time saving. Next to that, technology adoption results also in less isolation within the rural areas, because the women are more connected to each other through social media and emails (Hay & Pearce, 2014). However, access is not always linked to the infrastructure of big data, access to professional support will also have an influence in adopting technology as well (Hay & Pearce, 2014). This is supported by Mokotjo & Kalusopa (2010) as they state that the majority of farmers in Lesotho still do not have access to agricultural information systems. Another study was investigating the access of professional women in Zambia to information and communication technology (ICT) (Mulauzi & Albright, 2008). According to them, ICT can be useful in developing the women by providing them with knowledge about health, education, agriculture, environment, good governance and water and sanitation (Mulauzi & Albright, 2008). However, the access seems also to be a barrier in adopting the digitalization due to the high costs of equipment, maintenance and connectivity (Mulauzi & Albright, 2008).

Another benefit from adopting digital technologies in rural areas is that those firms now have access to educational videos and niche markets (Bello-Bravo, Tamò, Dannon, & Pittendrigh, 2018; Pant & Hambly Odame, 2017). Especially for firms in the agriculture, access seems to support the income diversification, however, farmers in Canada are still complaining about the fact that they do not have access to a better broadband connection or access overall (Pant & Hambly Odame, 2017). That access to technology results in poverty reduction is also studied by Cecchini & Scott (2003). They stated that ICT can give poor people and farmers access to education, health, government, financial services and new markets, but that this access lacks by its high costs. Also in Pakistan, access is still not optimal, according to Abdullah (2015) the infrastructure has to be improved in order improve the network development within its country and population. Key challenges in The Philippines to improve the infrastructure are access to communication, transportation and water resources (Chandra, Dargusch, McNamara, Caspe, & Dalabajan, 2017).

Access to computers seems not only outside Europe to be a problem. In Ireland only 63% of farm households had access to computers in 2011. Despite the fact that these numbers are increasing, Hennessy, Läpple, & Moran (2016) are stating that these numbers are still too low.

Missing institutions

Even when the access to digital technology is sufficient, there are more reasons why farmers struggle with implementing the technology within their farm. Another cause is the lack of supporting institutions that help farmers in their use and adoption of technology (Khanna, Swinton, & Messer, 2018). To illustrate, African countries face challenges in how to integrate new sources of knowledge within their farm to improve the food security, however there is still a lack of support in funding and direct links between farmers and researchers by institutions (Richards et al., 2009).

Lack of appropriate incentives

Another potential cause of not making use of digitalization is the lack of appropriate incentives. Cecchini & Scott (2003) stated that the implementation of digital projects must be executed by organizations and individuals who have the appropriate incentives to work with groups. Besides, Khanna et al. (2018) states that the adoption rates are often low due to behavioural factors and that those factors can be solved by appropriate incentives.

Age

Age seems to be an important aspect in the adoption of technology according to Daberkow & Mcbride (2003). The older a farmer is how less likely it is that this person is going to adopt digital technologies within his or her business. However, according to the results of Hay & Pearce (2014), this is for grazier women in Queensland not the case as other factors were more likely to hinder the implementation of digitalization technologies such as attitude and lower education.

Lack of involvement

To ensure the needs of the poor, such as access to technologies, education, and knowledge, the involvement of the community seems to play an important role. It is identified as one of the key factors that have influence on those needs (Cecchini & Scott, 2003).

High costs

As mentioned in ‘access’, a barrier of having access to digitalization can lay within its high access costs. These costs were divided by Mulauzi & Albright (2008) as costs in: equipment, maintenance, and connectivity. Many regions cannot afford it to improve their infrastructure as they are most of the time poor too. To improve the infrastructure, the decision makers have to consider the acquiring, installing and maintaining costs. Farmers do also face high costs in the extension of learning presentations since those are costly due to its resources, travel time and distance for extension agencies. However, hidden costs do also play a role in the adoption of digital technologies (Khanna et al., 2018). When we are looking at the adoption of big data within the whole agricultural value chain, Coble et al. (2018) states that the costs of big data

adoption are costly in terms of volume, however, the adoption of big data will eventually result in reducing operational and processing costs.

Education

Education seems to play a role in the adoption of digitalization technology as well. The study of Abdullah (2015) was examining the difference between castes in rural Pakistan and their use of digital technologies. He concluded that the use of ICT is dependent on the literacy of the people. Castes of farmers should be much more educated in order to make use of the technologies. Besides, Hay & Pearce (2014) state that the position of women in the agriculture will be diminished when they are not educated, but they also mention that lack of education is a barrier in adoption. Bello-Bravo et al. (2018) investigated in which way farmers can be educated better, they concluded that the use of animated videos among farmers was very effective and demonstrated greater learning gains than farmers who were using traditional technology.

Knowledge

Limited knowledge and skills for using ICT by farmers contribute to the challenges in adoption as well (Abdullah, 2015; Mulauzi & Albright, 2008). This can be supported by the study of Chandra et al. (2017) who were doing research on climate smart farming. They stated that climate-resiliency field schools can serve as a platform where farmers can gain information in order to improve their farm planning. However, they also mentioned that climate-smart interventions involve knowledge-intensive processes. Thus, knowledge can serve as a barrier in the climate-smart interventions if there is a lack of informative platforms. Regarding the lack of informative platforms, Bello-Bravo et al. (2018) suggests farmers in sharing their knowledge through videos.

Quality and internet usage

The quality is linked to the quality of access to internet by farmers. According to Abdullah (2015), the connection speed of broadband seems to play a role in the adoption of digital technology. Besides, the usage of internet among farmers were also indicating that farmers who do not use internet are often less likely to adopt ICT as well.

Language

Language is the last barrier in adopting digital technologies in farms. Languages within a country can differ a lot, because countries are using a main language but can also have many local languages. For example in Zambia the development information is accessed in eight languages Mulauzi & Albright (2008). It requires a lot of effort to translate knowledge and informative knowledge in order to serve every local group. When different groups of farmers cannot access the information in their language this can result in not making use of ICT by these groups.

The usage of digitalization

As shown in Appendix 2, there are seven barriers in the usage of digitalization in agri-food firms. These barriers will individually be explained with support of case studies found in the articles.

Data complexity

When the digital technologies are successfully adopted within a company, there will be generated a lot of data. This big data can be used by policy makers and decision makers in order to make good decisions. However, according to Saggi & Jain (2018), this data can be very complex due to its structure. This can lead to difficulties for decision-makers in order to process them. Soomai, Wells, & MacDonald (2011) supports this as they have noticed that the high technical content of information for fisheries are reducing its usefulness. This can be explained by a lack of formal systems that distribute or measure the use and influence of big data in decision making. Moreover, Tanure, Nabinger, & Becker (2015) have seen these issues among the managers in finding and selecting relevant information. A solution was given in a generalized mathematical bioeconomic model which managers can use for livestock production systems.

Lack of essential improvements

Another barrier that is influencing the use of digital technologies is the lack of essential improvements. Two different types of essential improvements will be explained. First of all, Bauwens & Pantazis (2018) were doing research on more relevant technological infrastructures within companies in order to generate more profit. However, they concluded that the higher-level forms of organisations need to improve in order to realize the profit as promised by the digital technologies. Another type of improvement lays within the services of the technology itself. Online calendar services are used for many different purposes within companies, such a reminding, scheduling, and tracking (Akoumianakis & Ktistakis, 2017). However, according to Akoumianakis & Ktistakis (2017), these services are appearing to be relatively weak nowadays and needs to be improved to ensure that those services are keep being used.

Gender differences

Studies to genders within the agriculture has shown some interesting results for decision makers. According to Hay & Pearce (2014), grazier women are using most of the digital technologies components three times more often than men. Despite the fact that gender divisions still exist, the increasing use of digital technologies in rural areas is diminishing this division. Mulauzi & Albright (2008) found that the access and use of digital technologies are hindered by marginalisation of gender, but that other variables, such as a language barrier, high costs, and limited skills and knowledge, are playing a bigger role in it.

Lack of modernity

Research into the technology use of farmers in Bangladesh showed that neither education nor income is a real barrier in the use of digital technologies, but that being modern is very important (Islam & Grönlund, 2011). Being modern is indicated by having children or being young since children nowadays are using technology more often. This means that when farmers have children or are from a younger generation they are more likely to use digital technology within their businesses, because this 'modern generation' uses it more often and thus face less barriers in in the usage of it. Farmers without children or from an older generation are thus less likely to use digital technology and face more problems in the usage.

Farm business characteristics

According to Hennessy et al. (2016), the usage of digital technology seems to depend on the business characteristics of farms and not on the access of digital technologies. Farms who have access to computers and use them in their household do not always use it in their business. This depends on the business characteristics of the farm since dairy farmers are more likely to use computers for their business twice more often than tillage farmers (Hennessy et al., 2016). They do not give clear explanations about the cause of this difference. However, an explanation for the difference between dairy farmers and tillage farmers can be that dairy farmers are making use of herd registers which can best be fulfilled in a computer, while tillage farmers do not have to register their cattle.

Lack of services

In the implementation of digitalization is mentioned that a lack of institutions is a barrier in adopting digital technology. However, also in the usage of digitalization seems a lack of services by institutions to be a barrier. According to Mokotjo & Kalusopa (2010), farms seem to hinder the usage of agricultural information services as a consequence of a lack of promotion and a lack of training on how to use these services. Besides, the high technical content which hinder fisheries in their decision making can be solved by institutional support (Soomai et al., 2011).

Lack of knowledge

Next to the six aforementioned barriers of usage it seems that some farmers are dealing with the lack of knowledge about digital platforms. According to Panagiotopoulos, Bowen, & Brooker (2017), farmers can use digital platforms in order to influence policy makers. This is a real issue, because farmers have to know how they can have influence on decisions which are influencing their own working area.

The consequences of digitalization

The third and last type of challenges is about the challenges that farmers face as a consequence of digitalization. As shown in Appendix 2 there are four kind of challenges that support this category of which 3 are mostly focussed on policy and management.

Policy

Big data can be used in policy making, but it has also the ability to evaluate policy decisions (Coble et al., 2018). Research claims that policy makers should focus on how they can support food production and marginalized agricultural labourers which are a consequence of the digitalization within the agricultural sector (Rotz et al., 2019). Besides the share of big data, Panagiotopoulos et al. (2017) states that farmers can use social media as well in order to influence policy makers, it is only a challenge for farmers how they should use these platforms.

Data management

Big data can also create a lot of concerns for policy makers and producers. As mentioned above, it can be used in for example policy. However, before making policy, this data must first be shared by farmers with the policy makers. But not every farmer is willing to share their data which subsequently results in a growing discussion between policy makers and producers about this data ownership and data protection. Currently there is no federal legislating about these issues, but this should be changed in the future (Coble et al., 2018).

Risk management

Farmers and other businesses are not the only persons who will use digital technologies. The population and media are using computers and social media as well. Boyd & Jardine (2011) did research on the risk framing of the media about mad cow diseases as media can increase the risk out of its actual proportion by their way of framing. The challenges created by this digital technology for farmers are how they have to deal with the risk framing of the media.

Development of a high-skill/low-skill bifurcated labour market

Since the costs of land are increasing, there is an enormous pressure for farms to save on other costs, such as labour costs (Rotz et al., 2019). A popular solution to save on labour costs is by replacing workers for machines. Consequently, the adoption of machines will result in a demand of high skill workers who are replacing the low skill workers, which will eventually bring shifts in the labour market. The adoption of technologies will lead to a need of retraining of the low skill workers or a search of other possible jobs.

Discussion

In this paper a systematic literature review has been used to get an overview of the existing challenges that agri-food firms face in adopting digitalization. The results have shown that there are three different types of challenges, those are: challenges related to the implementation, usage or as a consequence of digitalization. To conclude, it seems that most of the challenges are existing in the implementation part and subsequently in the usage of digitalization. Access is the most referenced challenge by the articles regarding the implementation of digitalization. Besides, it seems that most farmers are struggling with the data complexity when digitalization has been implemented and is generating data. Regarding the challenges as a consequence of digitalization it seems that most of the challenges take place within the management and policy levels.

Since I was excluding all papers that were not published within the journals classified as a 2 star or higher, I could have missed a lot of potential information about facing challenges as

the amount of including papers went from 508 to 39 articles. Besides, excluding reviews in my data set could have also caused missing challenges, so I will suggest for further research to adopt this category. Next to that, I have focussed myself on the 'social sciences area', however, including subject areas such as business management and accounting or engineering could also have given more and other types of challenges within the business. Lastly, all data was generated from the articles published in Scopus, however, despite the fact that Scopus has the largest database, I would suggest for further research to include other search engines as well to exclude possible missing articles.

This paper tried to contribute with giving insight in the challenges and providing knowledge for researchers and decision makers to make well-considered decisions about the adoption and its consequences of digitalization within their company. Besides, it has shown that those challenges are faced over a lot of countries in the world and some challenges are very complicated. Further research could map those challenges per country and give suggestions to the policy makers on how to deal with those challenges since this research has also indicated that the challenges can not always be solved by the farm itself. Furthermore, some barriers were contradicting each other, for example, Hennessy et al. (2016) stated that business characteristics are more important than access in adopting digital technologies. Further research can indicate which challenges are mostly hindering farms by making use of my categorization of challenges.

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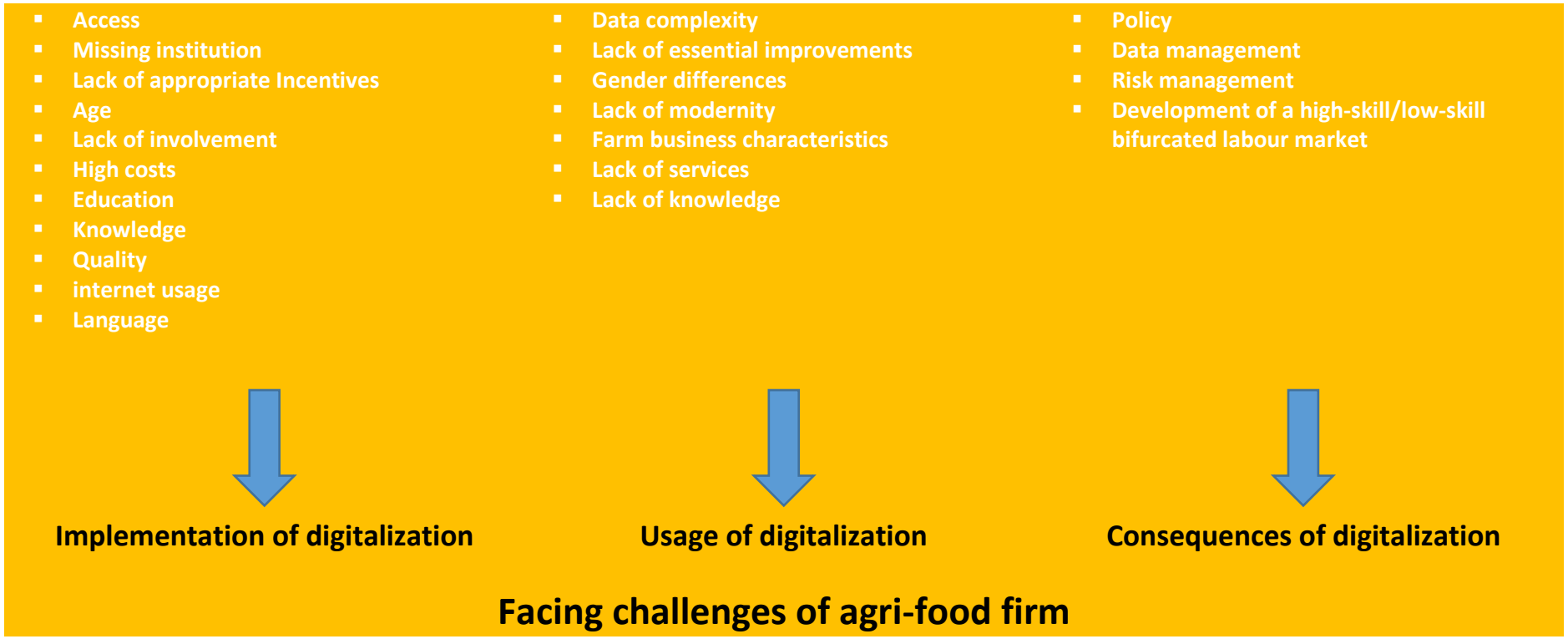
Appendices

Place in value chain \ Type of challenge	Implementation of digitalization	Usage of digitalization	Consequences of digitalization
Whole agricultural value chain	Coble et al. (2018)		
Farmer groups	Richards et al. (2009)	Akoumianakis & Ktistakis (2017)	
Farms and commons		Bauwens & Pantazis (2018)	
Agricultural firms in general		Saggi & Jain (2018) Tanure, Nabinger & Becker (2015)	Rotz et al. (2019)
Fisheries		Soomai, Wells & MacDonald (2011)	
Farms	Abdullah (2015) Bello-Bravo, Tamò, Dannon & Pittendrigh (2018) Hennessy, Läpple & Moran (2016) Khanna, Swinton & Messer (2018) Pant & Hambly Odame (2017)	Hennessy, Läpple, & Moran (2016) Islam & Grönlund (2011) Mokotjo & Kalusopa (2010) Panagiotopoulos, Bowen & Brooker (2017)	Boyd & Jardine (2011) Panagiotopoulos, Bowen & Brooker (2017)
Small farms	Cecchini & Scott (2003) Chandra, Dargusch, McNamara, Caspe & Dalabajan (2017)		
Grazier women → farms	Hay & Pearce (2014)	Hay & Pearce (2014)	
Professional women → farms	Mulauzi & Albright (2008)	Mulauzi & Albright (2008)	

Appendix 1: Type of challenges linked to its place in the agricultural value chain



Appendix 2: Theories of the challenges

Type of challenges	Theories	Authors
Implementation of digitalization	▪ Access	▪ (Cecchini & Scott, 2003) ▪ (Coble et al., 2018) ▪ (Abdullah, 2015) ▪ (Bello-Bravo et al., 2018) ▪ (Chandra et al., 2017) ▪ (Hay & Pearce, 2014) ▪ (Hennessy et al., 2016) ▪ (Mokotjo & Kalusopa, 2010) ▪ (Mulauzi & Albright, 2008) ▪ (Pant & Hambly Odame, 2017)
	▪ Missing institutions	▪ (Khanna et al., 2018) ▪ (Richards et al., 2009)
	▪ Lack of appropriate incentives	▪ (Cecchini & Scott, 2003) ▪ (Khanna et al., 2018)
	▪ Age	▪ (Hay & Pearce, 2014)
	▪ Lack of involvement	▪ (Cecchini & Scott, 2003)
	▪ High costs	▪ (Saggi & Jain, 2018) ▪ (Bello-Bravo et al., 2018) ▪ (Khanna et al., 2018) ▪ (Mulauzi & Albright, 2008)
	▪ Education	▪ (Abdullah, 2015) ▪ (Bello-Bravo et al., 2018) ▪ (Hay & Pearce, 2014)
	▪ Knowledge	▪ (Abdullah, 2015) ▪ (Bello-Bravo et al., 2018) ▪ (Chandra et al., 2017) ▪ (Mulauzi & Albright, 2008)
	▪ Quality	▪ (Abdullah, 2015)
	▪ Internet usage	▪ (Abdullah, 2015)
	▪ Language	▪ (Mulauzi & Albright, 2008)

Usage of digitalization	▪ Data complexity	▪ (Saggi & Jain, 2018) ▪ (Soomai et al., 2011) ▪ (Tanure et al., 2015)
	▪ Lack of essential improvements	▪ (Akoumianakis & Ktistakis, 2017) ▪ (Bauwens & Pantazis, 2018)
	▪ Gender differences	▪ (Hay & Pearce, 2014) ▪ (Mulauzi & Albright, 2008)
	▪ Lack of modernity	▪ (Islam & Grönlund, 2011)
	▪ Farm business characteristics	▪ (Hennessy et al., 2016)
	▪ Lack of services	▪ (Mokotjo & Kalusopa, 2010) ▪ (Soomai et al., 2011)
	▪ Lack of knowledge	▪ (Panagiotopoulos et al., 2017)
Consequences of digitalization	▪ Policy	▪ (Coble et al., 2018) ▪ (Panagiotopoulos et al., 2017) ▪ (Rotz et al., 2019)
	▪ Data management	▪ (Coble et al., 2018)
	▪ Risk management	▪ (Boyd & Jardine, 2011)
	▪ Development of a high-skill/low-skill bifurcated labour market	▪ (Rotz et al., 2019)

Appendix 3: Authors of the different theories