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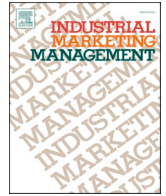
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# Exclusion and inclusion on business markets: Impacts of the Internet-Of-Things (IoT)

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## ABSTRACT

The implementation of IoT solutions transforms business-to-business markets. This transformation is not limited to technological changes. It also affects the actors and activities that characterize markets. We argue that the possibility of forms of exclusion / inclusion, as interpreted in Luhmann's theory, has important consequences for IoT solutions. Different from prior studies which have focused on why and how market-related forces exclude actors from a market, this research aims to provide a comprehensive overview of possible exclusion phenomena linked to IoT implementation in business markets, concerning its affected actors, mechanisms, and consequences. Using 'cold cases', this research uses case study methodology to identify potential forms of exclusion and inclusion. It then develops a framework that identifies different situations of exclusion and inclusion. Finally, it suggests avenues for future research and provides managerial implications for the actors concerned in this context.

## 1. Introduction

The Internet-of-Things (IoT) encompasses physical objects that are connected to the Internet via data communication technology (Andersson & Mattsson, 2015; Oberländer, Röglinger, Rosemann, & Kees, 2018). These unanimated objects are able to sense the external environment, communicate with it, or interact among themselves.

The IoT technology with its networked and modular nature has been seen as a powerful factor of change on business markets (Bunz & Meikle, 2017; Leminen, Rajahonka, Wendelin, & Westerlund, 2020; Porter & Heppelmann, 2014; Suppatvech, Godsell, & Day, 2019). More specifically, the implementation of IoT technologies on business-to-business (B2B) markets changes the interplay between actors, activities, and resources (Ferreira & Lind, 2023; Kees, Oberländer, Röglinger, & Rosemann, 2015; Pagani & Pardo, 2017; Pardo, Ivens, & Pagani, 2020; Pardo, Wei, & Ivens, 2022; Wieland, Ivens, Kutschma, & Rauschnabel, 2024; Woodside & Sood, 2017). IoT technology draws the attention of both B2B scholars and practitioners to new types of interactions, those established between machines or things (Hoffman & Novak, 2018; Woodside & Sood, 2017) with no or with very limited levels of human interventions.

The increasing importance of interactions without 'humans in the

loop' raises the question of who or what actually participates in economic exchange processes and who or what doesn't. It points to possible exclusion and inclusion phenomena on business markets that are triggered by the implementation of IoT technology. It also raises the question of the consequences of these exclusion and inclusion phenomena for the actors on B2B markets. Prior studies have focused on why and how market-related forces exclude actors from a market (Cova, Ivens, & Spencer, 2021; Geiger & Gross, 2018; Mele et al., 2018). However, limited research has studied how transformative technologies like the IoT create inclusionary and exclusionary effects on some actors in markets. Our research focuses particularly on exclusion processes as they involve a risk of generating undesirable outcomes both for individual actors and, more generally, for markets as a whole.

The purpose of this research is twofold: It aims to (a) provide a comprehensive overview of possible exclusion phenomena linked to IoT implementation in B2B contexts regarding its actors, "victims", mechanisms, and consequences, as well as to (b) illustrate these aspects of exclusion using a specific situation that beards the potential for exclusionary tendencies on business-to-business markets, that is, the arrival of Internet-of-Things (IoT) solutions.

To achieve these research objectives, we use Luhmann's theory of exclusion and inclusion and draw on a case study approach based on

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“cold case” data from a specific business-to-business (B-to-B) sector, that is, the agriculture sector. The agriculture sector is a useful field of study for three reasons: First, it is a sector with global relevance, farming takes place around the world. Second, farming plays a key role in several of the challenges human actors need to overcome in ensuring sustainable development. Third, farming shows rapidly increasing levels of digitalisation, it employs many of the digital technologies that are available today, such as sensor technology, autonomous driving, machine-to-machine communication, or digital twins.

Through these data we explore how IoT solutions create inclusionary and exclusionary effects. Based on our findings, we then develop a framework to explain the mechanisms and consequences concerning these effects. With the findings and the framework, we contribute to the literature on Industrial IoT by revealing the changing positions of humans in business contexts when IoT devices are adopted. We also confirm the transformative role of IoT by revealing the risks of exclusionary effects of the loose connections between humans and machines in business markets. We also expand the literature on exclusionary effects by shedding new insights into possible inclusionary / exclusionary effects of digital technologies.

In the following sections, we first explore different facets of exclusion in the literature. Next, we discuss our methodology of a case study approach based on “cold case” data. We then discuss possible exclusionary and inclusionary effects of the IoT and how this may affect business networks based on a framework we develop from our case study approach. Finally, we provide avenues for future research, both on exclusion/inclusion on business markets in general and on the more specific case of exclusion/inclusion as a phenomenon on business markets as triggered by the IoT.

## 2. Theoretical approach

In this section, we first present [Luhmann's \(1997\)](#) approach to social exclusion, based on his social system theory. We show that the concept of exclusion has already been used successfully in prior research to explore “marketplace exclusion”. We also show that Luhmann's social systems theory and his concept of exclusion have been proposed in academic literature to study technological phenomena that include interactions between humans and non-humans. Finally, we review several aspects of technological exclusion in the agricultural sector as it transforms under the impact of smart agriculture.

### 2.1. Luhmann's inclusion/exclusion approach

Luhmann conceptualizes the inclusion/exclusion problem at a societal level. For [Luhmann \(1997\)](#), society exists through communication ([Luhmann, 1984](#)) and is composed of different systems (for example, the economy, politics, law, science, religion, medicine). Each system fulfils a function in society. Each system has its “code” (health/illness for the medical system; payment/non-payment for the economic system, etc.) that gives its coherence to a system. Codes are used with respect to all the operations of a system. In contemporary societies people can participate in multiple functional systems and carry out system-specific operations ([Luhmann, 1997](#)). Organizations also operate within the context of the function systems, and they make decisions on including or excluding a person by utilizing a multiplicity of codes (e.g. economic, legal, scientific etc.) simultaneously ([Andersen, 2003](#)). Since functional systems are communication systems, inclusion means that a person is considered relevant in communication ([Luhmann, 2005](#)). For example, a school can use qualifications to decide whether a student can be enrolled into the school. If the student is enrolled, he or she will be part of the school's communication system, for example, receiving emails from the school or even being mentioned in these emails. Luhmann sees organizations as the driving force behind decisions about inclusion or exclusion ([Luhmann, 2000](#)). Or as [Braeckman \(2006, p. 78\)](#) puts it: “it is organizations which make decisions about inclusion and exclusion, not

the function systems themselves”. Hence, exclusion is not the result of an initiative that comes from an entire economy, nor – by the way – of an invisible hand. Rather, it is organizations that determine the inclusion and exclusion of other organizations, associations, non-governmental groups, local communities, and other actors. Organizations include or exclude people based on membership ([Luhmann, 2000](#)). They define the conditions of membership not only covering entry requirements but also behaviour expectations. For example, the student mentioned above not only needs to have the required qualification but is expected to perform well at school.

### 2.2. Luhmann's theory and the notion of marketplace exclusion

Luhmann's theory has already been introduced to the marketing field through the concept of marketplace exclusion. In consumer research, marketplace exclusion is relevant to the mechanisms through which certain individuals and communities are excluded from the resources and opportunities provided by the market ([Burgess, Kelemen, Moffat, & Parsons, 2017](#); [Saren, Parsons, & Goulding, 2019](#)). As a result, individuals and groups might not be adequately represented in the marketplace. In consumer research, marketplace exclusion has been related to several factors, such as poverty, age, race, disability, gender, sexual orientation, geography, and access to goods, services or technology, social class, and/or employment status ([Saren et al., 2019](#)). From Luhmann's perspective, these factors are like the codes or memberships used by organizations to decide whether an individual is included in a function system. Luhmann's theory has also been introduced to the BtoB marketing field to investigate how, why, by whom and with what exclusionary outcomes markets are shaped (e.g. [Cova et al., 2021](#)).

### 2.3. Using Luhmann to investigate technological phenomena

Several researchers have already discussed Luhmann's social system theory and the concept of exclusion in relation to information technology. Although these researchers are not that numerous, their work helps to pave the way for the use of Luhmann's theory and concepts to discuss phenomena of exclusion and inclusion which would also concern non-human actors.

[Esposito \(2017\)](#), based on Luhmann's work, explains that communication exists not when somebody says something but when somebody realizes that someone else said something. She considers that products and machines can be complex enough to “produce information different from what the user already knows” which is what Luhmann considers as communication. In that case “the user communicates with the machine even if the machine does not communicate with the user” ([Esposito, 2017](#), p. 258). She also specifically considers the IoT as a “network that connects machines, people, and real-world objects interacting with one another as people do in the web today. The idea is that objects can communicate with objects and people in the same way that people communicate with other people,” (p. 262).

[Braeckman \(2006\)](#), in her review of Luhmann's work, highlights that Luhmann has always situated his exclusion / inclusion perspective in the frame of systems theory. And the latter is not limited to the study of social relations between human individuals. She writes (p.66): “The inclusion/exclusion distinction thus refers to social inclusion or exclusion, even when it has non-social, e.g. political or economic, causes and/or implications.”

[Rafael \(2013\)](#) re-interprets Luhmann's “concept of technology being in the environment of society, and proposes instead that technology is, by itself, a subsystem of society”, still adding to the perspective that Luhmann's theoretical work allows analyzing human actor – technology actor interaction.

[Mavrofidis and Papageorgiou \(2013 drawing on the work of Luhmann\)](#), consider that the information and communication technologies function “as a system of inclusion (and thus exclusion as well) of those

social systems which do not conceive of the [information and communication technologies] as a prerequisite for their own continuation” (p. 1071).

Further support is formulated by [Herrera-Vega \(2015\)](#) who argues strongly in favor of employing Luhmann's theory to study and understand mixed human machine environments in which agency is not limited to the human side. In the same vein, [Richter \(2023\)](#) emphasizes that in Luhmann's theory there is no such dichotomy as culture / nature or human / non-human but only the functional distinction “system / environment”.

#### 2.4. Digital exclusion in the agricultural sector studies

Alongside studies that rely on Luhmann's concepts to discuss the phenomena of exclusion linked to information technologies, other research, without any reference to Luhmann, has also explored forms of “digital exclusion”. Among these studies, some are specifically interested in this phenomenon in the agricultural sector. This sector seems to be a good area for observing the transformations in practices brought about by digital technologies. Terms have multiplied to evoke this transformation (Smart farming, precision agriculture, Agriculture 3.0 or 4.0...), reflecting, according to several authors ([Herrero et al., 2021](#); [Jayashankar, Nilakanta, Johnston, Gill, & Bures, 2018](#)) a real “transition” justified by the need to more efficient agriculture ([Wolfert, Ge, Verdouw, & Bogaardt, 2017](#)).

Digital exclusion, in general, consists of two distinct problems: (1) individuals who are unable or unwilling to utilize the internet, and (2) individuals who have internet access but do not fully engage with digital services, which limits their potential benefits ([Nunan & Di Domenico, 2019](#)). It can result from a lack of skills, such as the skill set of digital literacy ([Klecun, 2008](#)). It can also result from a lack of access to ICT infrastructure ([Cushman & McLean, 2008](#)). Digital exclusion can also increase the risk of social exclusion due to the important role of digital technologies in communication ([Walsh, O'Shea, Scharf, & Murray, 2012](#)). Digital exclusion has become a main concern for individuals or groups with limited access to the Internet who might be excluded from the networked economy ([Friemel, 2016](#)). Individuals who lack internet access are unable to take advantage of services offered via digital means, and with the rise of “digital business,” they are at risk of being excluded from various commercial and public services (*ibid*).

In the agricultural sector, the use of smart technologies has been largely documented ([da Silveira, Lermen, & Amaral, 2021](#); [Herrero et al., 2021](#); [Fried, 2023<sup>1</sup>](#); [Jayashankar et al., 2018](#); [Llewellyn, 2018](#)) and its potential benefits emphasized. However, only a marginal research stream has developed to draw attention to potential dark sides of “smart farming” or agriculture 4.0 ([De Cremer, Nguyen, & Simkin, 2017](#); [Özdemir, 2018](#); [Rijswijk et al., 2021](#); [Rose & Chilvers, 2018](#)). Among these dark sides, exclusion phenomena have already been identified. [Klerkx and Rose \(2020\)](#) identify several potential inclusion and exclusion factors in agriculture 4.0. For instance, the costs of Agriculture 4.0 technologies can be prohibitive ([Barnes et al., 2019](#)), leading to certain actors being excluded for not being able to pay for it. Also “ingrained habits and lack of operating skills” ([Klerkx & Rose, 2020](#), p. 3) are mentioned to lead to the exclusion of certain actors from the digitalization of agriculture. In addition, authors mention that financial means that are dedicated to technological innovation in agricultural 4.0 are ‘diverted’ from other low-tech means that could reveal efficient, leading to the exclusion of actors who could have benefited from these means. It is also argued that digital technologies on which agriculture 4.0 is based depend on several actors that will see their power

reinforced with a risk of exclusion of other actors.

Moreover, several authors have insisted on the existence of different narratives associated with agriculture 4.0 that can lead to exclusion. For example, [Klerkx and Rose \(2020\)](#) show that the narratives of agriculture 4.0. being de facto technocentric, they contribute to excluding reflection on different aspects of a social treatment of food security issues or even on alternative paradigms of degrowth. Other stories of exclusion have been identified in the literature on agriculture 4.0 or smart farming. [Opola, Klerkx, Leeuwis, and W Kilelu \(2021\)](#) who study innovation in the Kenyan agricultural sector thus describe a “support” or “resource” narrative which refers to the “lack of material and immaterial resources for innovation” of certain actors (p. 630). The “grassroot” or “compatibility” narrative has also been described: it emphasizes the role played by “formal and ‘scientific’ knowledge and practices over local or informal ones” in the exclusion of local communities (pp. 630–631). Finally, the “political economy” narrative refers to the influence and control wielded by certain actors to make sense of exclusion. Since inclusion or exclusion is considered being relevant or not in communication ([Luhmann, 1995](#)), these narratives play a powerful role to reinforce the exclusionary effects in smart farming.

[Rijswijk et al. \(2021\)](#) propose that digital exclusion in agriculture is caused whether by access, design or complexity conditions of digitalization. Access conditions refer to “lack of access to the Internet and the cost of an application”. Design conditions refer for instance to bias in algorithms. Complexity conditions are about “the difficulty to make all parts of a system work”. In a similar perspective, [McCampbell, Rijswijk, Wilson, and Klerkx \(2021\)](#) propose three levels at which digital exclusion can take place. First there is a level of a (single) digital technology. This level deals with who has access to the technology and the data. Second is the level the authors call “digital package”. This level deals with who is excluded because of the design of the technology or the world representation it is carrying. Finally, there is the level of the “digital system”. This level deals with broader consequences of digital technology that excludes people and organizations from certain interactions. These conditions or levels imply the conditions of a kind of memberships, by which organizations, especially companies, can decide to include or exclude certain actors from a smart farming system.

### 3. Methodology

This research uses case study methodology. Specifically, it uses secondary data, i.e. cases that have been previously published in academic literature for research in IoT implementation in smart farming. Such a methodological approach is often referred to as cold case research ([Cova et al., 2021](#)) and has largely been described and discussed by [van de Sandt, Dallmeier-Tiessen, Lavasa, and Petras \(2019\)](#). The use of cold cases is not new in other social science disciplines. Scholars in sociology and health sciences have been encouraging the idea of data reuse and sharing for a long time ([Irwin, Bornat, & Winterton, 2012](#); [Moore, 2007](#); [Van den Berg, 2008](#)). More recently, researchers in the fields of consumer research and purchasing and supply management have been calling for the use and reuse of secondary data, especially qualitative data in research ([Ellram & Tate, 2016](#); [Rauf, 2022](#)). Recent publications in the fields of B2B marketing and supply chain management have also responded to this call ([Bhattacharya & Fayezi, 2021](#); [Cova et al., 2021](#); [Stevenson & Busby, 2015](#)). [Cova and Paraque \(2019\)](#) for example use cold-cases for their work on brand communities and [Cova et al. \(2021\)](#) for their work on marketplace exclusion.

The reuse of cases can be considered as a recontextualization of data ([Moore, 2007](#)). Qualitative data can be reinterpreted if the data is rich ([Silva, 2007](#)). The benefit of using cold cases is that the case data sets are often already validated ([Ellram & Tate, 2016](#)). There is also generally a nice description of a dataset, especially its context ([Ellram & Tate, 2016](#)). The reuse of data is also helpful when studies focus on similar contexts ([Rauf, 2022](#)).

<sup>1</sup> [Fried, 2023. Three Agriculture Technology Trends To Watch In 2023 at <https://www.forbes.com/sites/forbesbusinesscouncil/2023/02/14/three-agriculture-technology-trends-to-watch-in-2023/?sh=15c7d62641c1> \(accessed 102 october 2023\)](#)

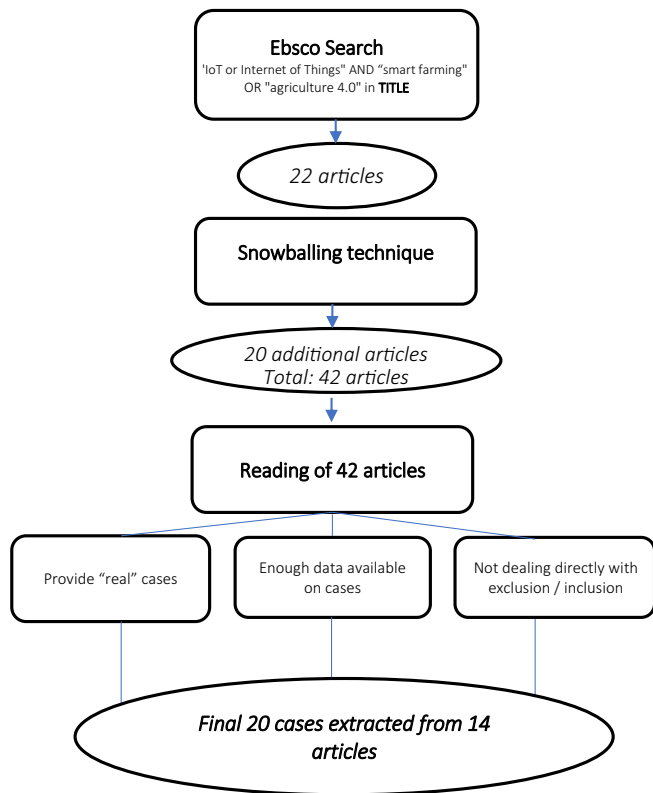


Fig. 1. Case selection process.

Since our research focuses on the context of IoT solutions in the agricultural industry, our cold case data share similar contexts with our research. The selected case-based articles also have detailed descriptions

of their contexts, and the richness of the case data allows us to re-contextualize and reinterpret to develop a new framework. Therefore, the use of cold cases is suitable for our research, and it also responds to the recent call for reusing cold case data in marketing research.

### 3.1. Data collection

To start with case identification, we made a series of queries on Ebsco databases to identify cases that serve our needs. We searched for articles with ‘IoT or Internet of Things’ AND ‘smart farming’ OR ‘agriculture 4.0’ in the title using the EBSCO database. The search gave 22 hints. We also used the references given in those articles to gain access to new potential cases (snowballing technique). This resulted in an additional list of 20 articles.

We read all 42 articles and retained articles that present qualitative case studies (certain articles are presenting several cases). We excluded cases if their focus was explicitly on exclusion or inclusion as a research issue. This decision was taken to avoid any bias in the findings of this research. Cases that were selected are descriptions of IoT systems being implemented in the agriculture sector. We checked that the cases descriptions were providing enough information about: the context (which type of farming activity is going to be equipped with IoT); the type of hardware that is going to be used (sensors, cameras, etc...); the type of measures that are going to be made (temperature, weight, moisture, chemical composition, wind, etc.); the applications for the user (the farmer). Based on these two restrictive dimensions (no direct reference to exclusion/inclusion issues and enough information provided) we built a first final list of 20 cases extracted from 14 articles (see Fig. 1). The final analysis was therefore made on 20 cases (see Appendix 1).

### 3.2. Data analysis

The cases represented an amount of 6127 words. We open coded this material using the terms that are present in the cases thus respecting the

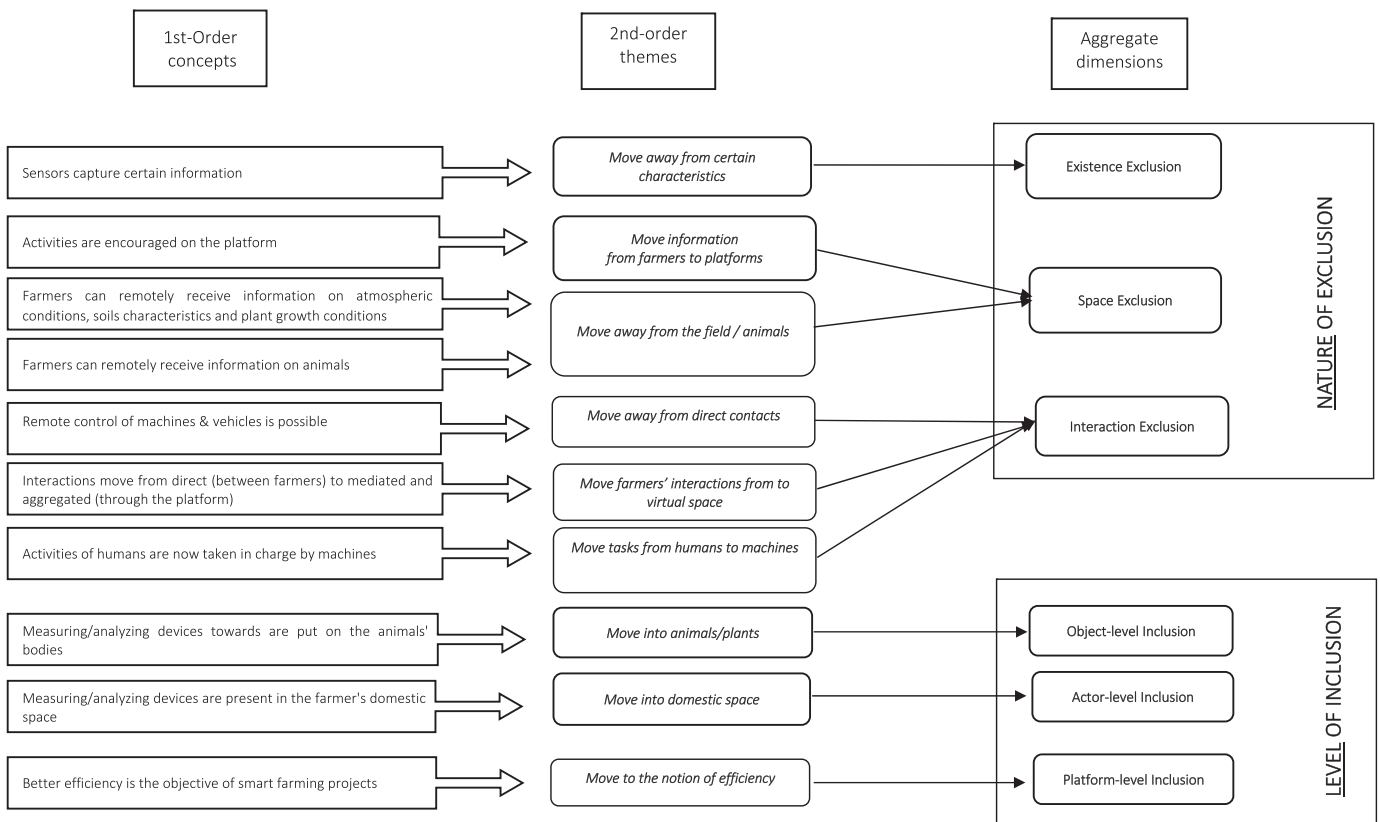


Fig. 2. Coding process.

indication given by Gioia et al. (2013, p. 20) to “faithfully adhere to informant terms”. Many categories relating to how IoT systems are implemented in farming contexts emerged from this 1st-order analysis. We seek for “similarities and differences” (Gioia et al., 2013, p. 20) and identified 10 concepts. (see Fig. 2). Then we moved to a second step of our analysis. Our objective, in this 2nd-order analysis is to determine whether these concepts are suggesting link with the “theoretical referents in existing literature” (Gioia et al., 2013, p. 20). We were unable to clearly make the link with the concepts of exclusion and inclusion. Instead, we identified four types of “moves” that the ten concepts could be linked with. On the one hand, things, people or activities were (1) totally moved *away* (they disappear...), or (2) moved *from* a place to another one. On the other hand, things, people or activities were (3) moved *in* a place or (4) moved *toward* a place (they move in the direction of...). Then we aggregated the themes considering that “moves out” or “moves from” refer to an exclusion phenomenon while “moves in” or “moves toward” refer to an inclusion phenomenon. By doing so we were building both on the definition of marketplace exclusion (activities of actors that prevent another actor from entering a physical, digital, or conceptualized space/place or drive her/him from this space/place) and also the definition of digital exclusion (exclusion at different levels) that are both pointing to what/who is “in” and what is “out”.

**4. Findings: Risks of exclusionary IoT practices**

In this section we comment on the different moves that we identified in the description of the implementation of the IoT systems.

**4.1. Moves away as possible exclusion situations**

The IoT cases that we analysed describe the different measures that the sensors equipping the fields (Case GRAPEVINE MILDEW), the equipment (case RABBIT FARM; case HENS), the vehicles (case JOHN DEERE), and the animals (case COWS; case HENS) are making. These measures capture temperature, pressure, moisture, wind, weight, position, etc. Though various, these measures only represent a limited aspect of what happens in a specific context. For instance, the RABBIT FARM project proposes measurements of volume, humidity and temperature of the grain in the silo. However, what about the detection of the intrusion of an animal in the silo? By choosing what to measure, sensors, automatically exclude certain dimensions to be considered. This was labelled as a “move away” (certain characteristics of things or events are not measured and consequently not considered: they are excluded from consideration. They disappear). We considered this as an “exclusion” phenomenon.

Sensors equipping machines and vehicles communicate remotely information to users. In the JOHN DEERE case, for example, the IoT project is described as allowing for ‘remote managing of machines and operations’. In the THAI ORGANIC VEGETABLE, operation can be monitored and managed from a distance via smartphone and tablet devices. This was also labelled as a “move away” (the direct contact between vehicles, equipment and farmers disappear). We also considered this as an “exclusion” phenomenon.

Several cases (FERTILIZERS; THAI ORGANIC VEGETABLES; TREES) describe how the IoT allows farmers to receive information remotely without being on the field. With sensors capturing data directly on the soils, trees or plants, farmers are excluded from the field. This does not mean this exclusion is voluntary or mandatory, it is rather provoked / allowed by the technology itself. This was labelled a “move away” (move of farmer away from the field) and considered as an “exclusion” phenomenon”.

In addition to the previous point referring to a move outside the field, because of sensors put directly on the animals' bodies (to measure their position as in the HENS and GEOFENCING cases), behaviours (as in the DISEASE DETECTION case) the contact between the farmer and the animals (whether it is visual or manual) is no more necessary. We

Natures of potential exclusion

Existence exclusion	1	2	3
Spatial exclusion	4	5	6
Interaction exclusion	7	8	9
	Entity inclusion	User inclusion	Platform Inclusion
	Levels of potential inclusion		

Fig. 3. Exclusion / inclusion matrix.

labelled this also a “move away” (a move of farmers away from animals) and considered it as an “exclusion” phenomenon.

**4.2. Moves from as possible exclusion situations**

Several of the projects analysed indicate how data collected by the sensors are gathered on a platform (Case MIMOSA TEK; case JOHN DEERE). Case MANURE, for example, indicate that “farmer's information is saved in the system”, in that case the composition of the soil is given by farmers, the sensors only capture PH and temperature. We labelled this a “move from” (because there is a move of information from the farmer to the platform) and we considered it as an exclusion phenomenon.

In the JOHN DEERE case, it is indicated that “users are encouraged to find solutions on the platform”. In the HYDROPONY case, users can exchange opinions and experiences on the platform. So, in several IoT contexts, the IoT platform replaces the direct face-to-face interactions between farmers. We labelled this a “move from” (because there is a move from direct face-to-face relationships between farmers to indirect ones) and we considered it as a phenomenon of exclusion.

Both the COFFEE case and the TREES case mention the impact of the IoT system on human activity. In the COFFEE case, the IoT system replaces the production estimate traditionally done with direct measurement. In the TREES case, the IoT system reduces the manual visit to one. This was labelled a “move from” (as activities move from being handled by humans to being carried out by machines). We considered this as an exclusion situation.

**4.3. Moves in as inclusion situations**

In several cases we have descriptions of how the animals' bodies are equipped with sensors. In the case COWS FEEDING, cows are equipped with a neck collar. In the case HENS each hen wears a RFID tag. In cases GEOFENCING, DISEASE DETECTION, or MILKING wearable sensors are placed onto the cow's neck, tail, or leg. We labelled this, a “move in” (as devices are now moved to the animals' bodies) and considered this as an inclusion situation (devices are, in a way, included in the animals).

Sensors that record information at the animal, plant, and equipment level send data to specific devices that must now be included in the farmer's home environment. This is the case of computers, tablets, and

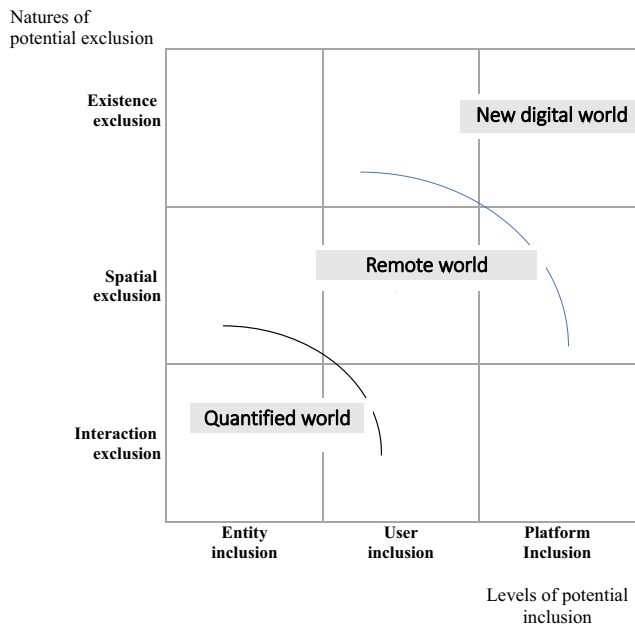


Fig. 4. Three IoT worlds.

smartphones. This result is in line with the description given by Rose et al. (2018) of the importance taken by “the office” as a place on the farm when computer-based decision support systems are used. This was labelled as a “move in” (as digital devices are put in the farmer's domestic space: his house, his pocket...), and we consider it an “inclusion phenomenon”.

4.4. A move to as an inclusion situation

Though different aspects of quality of products and production, limitations of intrants, water economy, and even animals' wellbeing are mentioned, the IoT projects move all discourses toward the notion of efficiency. The purpose is to optimize the use of resources with the use of IoT. A possible alternative of a degrowth is never mentioned. (see also Rose, Barkemeyer, de Boon, Price, & Roche, 2022; Zagata, Sutherland, Hrabák, & Lostak, 2020). We labelled this a “move to” and considered this as a phenomenon of inclusion in the sense that it includes the actors of the IoT system in a sole paradigm of efficiency.

5. A conceptual framework

5.1. Different natures of possible exclusion and inclusion

The different ‘moves’ (or transformative changes) that are possibly caused by IoT systems in business-to-business contexts can materialize in different forms. We propose that these different forms are aggregated in different natures of potential exclusion and different levels of potential inclusion (i.e. levels at which data access is included). For both dimensions, that is, inclusion and exclusion, we distinguish three situations:

Regarding the risk of exclusion, we consider that there are risks of exclusion of the farmer (or other human actor) from:

- a direct interaction with someone or something (a human actor, an animal, or a thing) and replacement with some form of interaction mediated by a IoT system. We call this *interaction exclusion*,
- a physical location related to the business context (e.g., a farm). In this case, the actor does not have access to the context in which

professional interactions with other human actors, animals, or things usually take place. We call this *spatial exclusion*.

- certain types of information (and, consequently, from interaction with actors or resources) because certain characteristics (e.g., well-being, emotions, aesthetics...) of human actors, animals, or things are no more measured. There are risks that traces of the very existence of these characteristics will be lost. We call this *existence exclusion*

Regarding the potential inclusion, here we consider at what levels new devices supporting IoT systems are located. They are located at the levels of things and animals, at the level of users and at the level of multiple stakeholders. We thus consider that:

- devices producing, processing and transmitting data are included on (or even in) things and animals. We call this an *entity<sup>2</sup> inclusion*.
- devices producing, processing and transmitting data are included in the farmer's “sphere”. Decisions are by the farmers and are supported by different data at the level of the farm. We call this a *user inclusion*
- platforms as devices producing, processing and transmitting data are created at the level of different stakeholders. Decisions making can be supported or even totally automated by the platform's algorithms with a unique objective of efficiency. We call this a *platform inclusion*.

The three forms of possible inclusion and exclusion can occur in several combinations (see Fig. 3).

- Field 1 (existence exclusion and entity inclusion): Farmers receive the source of data but only consider the data provided by sensors. Consequently, they visit the farms less frequently. They ignore some conditions due to less frequent visits or lack of sensor monitoring. Poor performance might take place due to poorly informed decision making.
- Field 2 (existence exclusion and user inclusion): Farmers receive data collected by sensors via an application and makes decisions on that. They do not visit their farms and have no interaction with the animals and plants. They ignore some conditions due to lack of sensor monitoring and lack of data from other stakeholders. Thus, performance might be affected due to lack of information.
- Field 3 (existence exclusion and platform inclusion): Other stakeholders and the farmer receive data coming from the sensors but do not need to have physical contacts neither with animals, equipment & ground. Decisions are made based on algorithms, but with a few mistakes due to some conditions not monitored by sensors. Farmers can be completely excluded from the farm due to automatic decision-making processes.
- Field 4 (spatial exclusion and entity inclusion): Farmers do not come to the field. They have remote access to data about animals, equipment & ground. But data is not integrated, it is received from each point of data production. Decisions are taken at the level of one living being or thing. Poor performance might take place since contextual factors are ignored and data is not integrated.
- Field 5 (spatial exclusion and user inclusion): Farmers do not come to the field. They have remote access to data about animals, equipment & ground. Data is integrated/processed/ by the farmers. Decisions can be taken at the level of farms. Poor performance might take place since contextual factors are ignored.
- Field 6 (spatial exclusion and platform inclusion): Other actors than farmers have access to data about animals, equipment & ground, but

<sup>2</sup> We refer here to « entity » to also consider non- human actors. See Baygi, Introna, and Hultin (2021).

neither they nor the farmers come to the field. Decision can be taken outside the farms based on algorithms. But performance might be affected due to lack of data about the farms' contextual factors.

- Field 7 (interaction exclusion and entity inclusion): Farmers do not need to have physical contacts with animals, equipment & ground. They have access to data about each of them. The farmers come to the source of data to “collect” data at each point of data production. Decisions are made based on the data, their understanding of the farms' context and their experience.
- Field 8 (interaction exclusion and user inclusion): Farmers do not need to have physical contacts with animals, equipment & ground. They have access to data about them, but remotely. Integrated data is presented to the farmers. Decisions are made based on the integrated data, the farmers' understanding of the farm's context and their experience.
- Field 9 (interaction exclusion and platform inclusion): Farmers do not need to have physical contacts with animals, equipment & ground. They still come to the farms, try to understand the contexts and find out what might have been missed by the platform. The farmers get data from other stakeholders via the platform. Other actors than the farmers have access to data about the farms too. But the farmers can reject the recommendations from the platform based on their understanding of the farms. Farmers cannot be completely excluded.

### 5.2. The impacts of IoT: Performance and risks

Performance of the farming processes can be enhanced by the IoT systems or not. As our analysis reveals, when farmers face a higher level of exclusionary effects, good farming performance might not take place if they cannot integrate suitable IoT devices with a higher level of inclusionary effects. This is because the void created by excluding farmers cannot be filled completely by the chosen IoT devices. When farmers are unable to visit their farms regularly, certain vital aspects of their crops and land may go unmonitored by IoT devices. Less informed decisions will be made due to a lack of data. Therefore, the performance of farming processes depends on data availability, consistency, accuracy and coverage. When some characteristics are not monitored by IoT devices or some tasks are not performed by the IoT devices, farmers should develop practices to complement IoT devices. They should also identify suitable IoT devices and understand the inclusionary and exclusionary effects of these devices. Therefore, the performance of business processes (i.e. farming processes) depends on the matching between exclusionary levels and users' complementary practices.

When adopting IoT technologies, farmers also face the risk of having fewer direct interactions with reality due to their reliance on its virtual representations. Since these direct interactions allow farmers to be aware of different characteristics in the farms, a lack of these interactions can lead to the risk of making ill-informed decisions, when virtual representations cannot well represent and fully cover the reality. In addition, when the inclusion level of IoT devices is high, IoT devices with supporting algorithms monitor and automate the farming processes. Consequently, decision making process has less human involvement. Farmers can face the risks of being completely excluded from business processes (i.e. farming processes) and even markets when IoT systems have data integration and algorithms.

### 5.3. Interactions between possible exclusion and inclusion

We further generalize the interactions between exclusion and inclusion and propose a general framework of three types of interactions between the two concepts (see Fig. 4).

The first type reflects a *quantified world* where we observe entity inclusion and interaction exclusion. At this level, by using sensors and IoT devices, farmers attempt to get some data to support their experience-based decision making. Based on the data, they can quantify

the characteristics in their farms, shifting from decision making based on informal experience or knowledge to the one based on formal or scientific knowledge.

The second type reflects a *remote world* where there are user inclusion and spatial exclusion. At this level, by increasing the applications of IoT devices in their farming processes, farmers develop greater dependence on IoT devices and the data they produce in decision making. A distance is developed between farmers and their farms as they perform farming tasks with the support of data visualization and IoT connected farming machines, rather than visiting the farms and performing these tasks themselves.

The third type reflects a *new digital world* where we observe platform inclusion and existence exclusion. At this level, farming tasks can be performed independently by the IoT platforms. Sensors collect data from and outside the farms and algorithms in the IoT platforms analyse data, make decisions and automate farming processes. Consequently, farmers can be completely excluded from the farming process.

These three types of interactions between exclusion and inclusion reveal a pattern due to the adoptions of IoT technologies: when farmers integrate or include devices producing, processing and transmitting data into their farming processes, while more data (refined into information) increases opportunities to manage processes better there is a risk for them to be excluded from farming contexts and farming processes.

## 6. Discussion

Overall, IoT systems offer broad opportunities in business-to-business contexts. Our ‘cold case’-based case study analysis of the specific setting of agricultural markets suggests that there are opportunities and risks associated with IoT offerings regarding both exclusion and inclusion.

### 6.1. Theoretical implications

With our findings, we contribute to the literature on Industrial IoT by improving knowledge on IoT in BtoB contexts. While prior research focuses on issues of adoption or new business models (Hakanen & Rajala, 2018; Jayashankar et al., 2018; Leminen, Rajahonka, West-erlund, & Wendelin, 2018), our research offers new insights into IoT adoption by revealing its impacts on interactions between humans and their relevant business contexts. Our findings reveal the changing positions of humans in business contexts when IoT devices are adopted in business processes at different levels. Our paper also offers a new perspective on IoT adoptions, that is, looking at the matching and complementarity between IoT devices and human roles.

Moreover, our study confirms the transformative role of IoT (it changes the nature of actors, activities and resources). While previous research on Industrial IoT has focused on loose connections between machines and between humans and machines (Pardo et al., 2022), our research has further delved into the exclusionary effects of these connections. In addition, while prior research has focused on how digital resources can create new activities in value co-creation due to their autonomous nature (Pagani & Pardo, 2017; Pardo et al., 2022; Wei & Pardo, 2022), our research indicates that specifically the autonomous nature of digital resources might create risks for human actors to be excluded in and from these activities (Rochi, Rauschnabel, Renner, & Ivens, 2024). Therefore, our research raises concerns of the dark sides of interacting with digital resources in business networks and proposes that complementary practices need to be developed to manage the exclusion effects.

Our study also expands works on exclusionary effects (to respond to the call by Cova et al., 2021) with a focus on inclusionary / exclusionary effects of digital technologies. Prior literature has indicated that tightness of boundary and actor irrelevance are two factors that explain why certain actors are excluded from a market (Cova et al., 2021). Following these earlier findings, our research has offered an in-depth explanation



into why human actors become irrelevant and face the risks of being excluded from resource interactions, business contexts, and broader markets. Based on the previous concepts of exclusions and inclusions (e. g. *Cova et al., 2021; Luhmann, 1995; McCampbell et al., 2021*), our research has also proposed new conceptualizations of exclusion and inclusion, which can help better capture exclusionary effects human actors face in digital networks and the increasingly influential roles digital technologies play in shaping business networks and markets.

## 6.2. Managerial implications

Based on our findings, we offer managerial implications to both managers in companies and policy makers in public administrations.

First, this research provides advice to users of IoT systems. We see three important points. We encourage IoT system users (a) to precisely assess how the adoption of IoT systems is potentially “moving” things and actors, and (b) to identify which type of knowledge is going to be redefined by IoT systems and (c) how, consequently decision making is transformed. In the specific setting of the case research we have conducted, farmers should be careful of the risk of taking decisions relying too strongly on the virtual representation offered by the IoT while IoT devices might not cover and monitor all the characteristics in a context. Without such an understanding of how IoT devices are changing the connection between living beings, between living beings and artifacts, and between artifacts there is a risk of users making weaker decisions because they are less well-informed.

Second, because of the existence of different levels of exclusion, this research also highlights the importance of users of IoT systems complementing the data collected by IoT systems with their own knowledge. An IoT device typically provides a specific type and amount of data; as a consequence there is other data it can't provide. We suggest managers reflect on the type of data that their IoT devices provide as well as on the limits of this data in order to understand where they still need to use their own business knowledge to complement these data for decision making. As such, they can better work with the IoT devices and enhance the overall performance of their business processes. We also suggest managers analyse and identify the risks of using IoT systems in their business processes. For example, they should analyse the weakening role of their employees and offer guidelines on complementary practices to their employees. As such, they can better manage the risks of excluding their employees in business processes.

Additionally, our research also has implications for companies selling IoT systems. These companies need to understand the different profiles of their customers and users and how they are going to integrate IoT systems with their already existing resources. In particular, these companies should pay attention to work habits of their customers so as to be able to demonstrate how IoT systems can complement and not automatically replace existing knowledge and practices. Based on this understanding, they will be able to select, combine and propose more adapted IoT solutions. Finally, they need to further advise users on how to work with IoT systems. The adoption of an IoT system is only a first step in their relationships with customers. Potential dark sides may manifest only in the long run. So companies should establish a comprehensive representation of the entire journey their customers are going to go through, including different types of customer experiences along customer touchpoints. Finally, we invite companies to inform the adopting companies and users of the risks of using IoT systems arising from the exclusionary/inclusionary effects, such as data coverage, data integration, process automation, and changing roles of their employees in business processes. By clearly indicating potential technology dark sides, supplier companies and customer companies can better collaborate to integrate IoT systems with existing, more traditional practices.

Finally, this research provides public policy recommendations to policy makers in public administrations. We encourage them to develop comprehensive policies to regulate the use and sharing of the data collected by IoT systems. Since data coverage is playing an important

role in influencing the performance of IoT systems, how to gather and share data becomes crucial to IoT system developers and users. However, regulations and guidelines should be developed to inform users what data they will get from their IoT systems so that responsibilities can be clearly divided among stakeholders. Regulations and policies should be also developed to regulate sharing and usages of data gathered from IoT in order to protect the rights of different stakeholders. As data gathered by IoT and the resulting automation of processes can potentially exclude human actors, policy makers and regulators should offer sufficient information about the risks to the users of IoT systems. More attention and more support should be offered to the IoT users who could be marginalized due to industrialization and digitalization of production processes (such as farming processes).

## 7. Conclusion and avenues for future research

This case study research has been able to identify aspects of inclusion and exclusion that actors - and in the case of this research more particularly farmers - should take into consideration in connection with their use of IoT technology. We observe that actors need to actively understand what consequences a certain level of IoT exclusion and inclusion may generate for their own knowledge of their professional activities and, hence, for the future competitiveness of their economic activity, in our case more specifically their agricultural business.

Inclusion means concentrating data on a specific place. Exclusion means losing contacts and, hence, knowledge. Every type of inclusion is also an exclusion and vice versa. Every type of exclusion and inclusion has positive and negative consequences. Inclusion means also a risk of being kept from specific data or knowledge. And every type of exclusion, may, on the contrary, allow accessing specific data. Every manager needs to consider and decide what the best constellation is for her / his organisation.

At the same time, this research provides important insights for other actors in the relevant business ecosystem, highlighting their own role and possible changes brought about by IoT technology. Our work thus points more generally to the importance of not only understanding one's positioning in the business ecosystem, but also to the dynamic aspects of this positioning. The latter is not fully controlled by individual or organizational human actors, but increasingly determined by technology and its use (*Wei, Vize, & Geiger, 2022*).

Future research should attempt to find empirical evidence for the relevance of the different combinations of inclusion and exclusion on industrial markets, whether they focus on farming or other activities and resources. Such research may also wish to take into consideration different levels of technological development or also cultural factors. For example, the inclusion of artificial intelligence technologies and passive wireless sensors into IoT systems might potentially create more exclusionary effects on industrial markets.

Finally, IoT systems exist in many industrial sectors. While there is a wealth of systems and possible applications in farming, future research should analyse further business contexts in order to study exclusionary risks and inclusion levels, thus verifying whether the findings of the present research can be generalized across industries.

## CRedit authorship contribution statement

**Björn Sven Ivens:** Writing – original draft, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Catherine Pardo:** Writing – original draft, Resources, Investigation, Data curation. **Ruiqi Wei:** Writing – original draft, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

## Declaration of competing interest

None.

## Data availability

No data was used for the research described in the article.

## Appendix 1. Cases description

Case	Name	Type of IoT project	Details	Source
1	MIMOSA TEK	Crop management	An IoT system to monitor and govern irrigation infrastructure. It computes different environmental parameters in an entire growing area. An IoT platform collects data stored in the monitoring devices. A mobile application allows users to control the irrigation equipment at any time.	Haaker, Ly, Nguyen-Thanh, and Nguyen (2021)
2	JOHN DEERE	Farm operations	An IoT system to manage different farm operations, optimize fertilization, irrigation and harvesting conditions. The system associates John Deere and several partner applications. It provides tools for users to determine the factors affecting yield, understand what action to take based on agronomic information and information reflecting field conditions, and remotely manage machines and operations.	Leminen et al. (2020)
3	GRAPEVINE MILDEW	Crop management	An IoT system to control grapevine downy mildew. The system is composed of multiple sensors (for temperature, humidity, pressure, soil temperature, wind speed, leaf humidity, and precipitation) installed throughout the field to collect, pre-process, and transmit data to a cloud platform. Thanks to sensors measurements, field monitoring and depending on the growth stages of the vine, disease prediction is improved.	Popović et al. (2017)
4	COFFEE	Crop management	An IoT system that estimates coffee production from climate data, weather data and crop management data using machine learning models. The platform shows the production graph with the real data vs. the estimate and indicates the accumulated one per year.	Rodríguez, Montoya-Munoz, Rodríguez-Pabon, Hoyos, and Corrales (2021)
5	THAI ORGANIC VEGETABLES	Crop management	An IoT system to plan the production of fresh organic vegetables in a plant factory. The IoT-based technologies allow farmers to plan their production by using mobile devices for monitoring and controlling their farming systems.	Santiteerakul, Sopadang, Yaibuathet Tippayawong, and Tamvimol (2020)
6	ARABLE FARMING	Crop management	An IoT system for potato, wheat and soybean crop management. Sensors capture information crop cultivation and storage. External data (earth observation; economic data) are linked to the sensor network. All data is translated into the farm management system.	Verdouw, Sundmaeker, Tekinerdogan, Conzon, and Montanaro (2019)
7	COWS	Animals' management	An IoT system for geolocation of cows. Real-time sensor (for example installed on the neck of animals) data is used with GPS location. Data allows better information on cow feeding and reproduction.	Verdouw et al. (2019)
8	FRUITS	Supply chain traceability	An IoT system used to monitor the entire fruit supply chain from farm to retail. Sensors are installed in orchards and vineyards and used with traceability services (RFID)	Verdouw et al. (2019)
9	VEGETABLES	Crop management	An IoT system for managing outdoor vegetables growing. Sensors measure the conditions of the crops. The system aims to improve production control and communication throughout the supply chain (including harvest forecasting, consumer information).	Verdouw et al. (2019)
10	MEAT	Supply chain traceability	An IoT system that aims to optimize animal growth. Sensors located at different levels of the supply chain capture events and generate data that is used for meat traceability and early warning. Information on the health status of animals aims to reduce the use of antibiotics.	Verdouw et al. (2019)
11	MANURE	Crop management	An IoT system that aims to help farmer assess the composition of manure for a particular field. Sensors capture soils parameters, but the system also uses historical data and (acquired through surveys and databases). The result is a digital message sent to the farmer with a recommendation considering the forecast weather.	Ather et al. (2022)
12	FERTILIZERS	Crop management	An IoT system that provides farmers with information on soil nature and moisture. Different types of soil sensors are used to measure soils moisture and temperature. The result is a GSM message sent to the farmer's smartphone with plants irrigation requirements and a suggestion for the supplementing the soil.	Ferehan, Haqiq, and Ahmad (2022)
13	RABBIT FARM	Animals' management	An IoT system for smart feeding of rabbits in a rabbit farm. It aims to more efficient management of the quantity and quality of cereals for feeding rabbits. Sensors measure grain level, temperature, and humidity. The system offers a smartphone application that displays data on the conditions of the grains inside the feed silo.	Agrawal, Prieto, Ramos, and Corchado (2016)
14	HYDROPONY	Crop management	An IoT system that aims to control bicarbonate in water used for hydroponic agriculture. Sensors measure pH and an algorithm hosted on a central server automates water analysis. An alert can be sent to the user if a water quality defect is identified.	Cambra, Sendra, Lloret, and Lacuesta (2018)
15	HENS	Animals' management	An IoT system that aims to analyzing the laying performance of hens. Hens wear an RFID tag on one leg and there is an egg-detection sensor in each nest box which can detect whether an egg is laid and its weight. The system allows egg producers to compare individual yield rate with group yield rate and determine which hens should be culled.	Chien and Chen (2018)
16	IRRIGATION	Crop management	An IoT system that enables automatic measurement of soil water content at different depths and provides fast and accurate irrigation management information. The system uses drones-generated imagery (crop-based approach) and soil sensors to determine soil moisture (soil-based approach).	Kamienski et al. (2019)
17	TREES	Crop management	An IoT system that aims to establish automated global monitoring of insect infestations on trees. Accelerometer-based sensors are used to transmit short	Potamitis, Rigakis, Tatlas, and Potirakis (2019)

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(continued)

Case	Name	Type of IoT project	Details	Source
18	GEOFENCING	Animals' management	vibrations originating from an internal part of the tree due to the feeding noises from the larva. The data transmitted provides information on the infestation status of the tree. It enables data capture when manual practices are not possible. An IoT system that allows animals to be tracked. Cattle hers are equipped with a hardware device which consisting of different sensors and GPS tracking unit. Whenever an animal enters or leaves an area it triggers an alert for the farmer.	Akbar et al. (2020)
19	DISEASE DETECTION	Animals' management	An IoT system that aims at automatically detect cow diseases. When there are a lot of animals, checking each animal daily is impossible and takes a lot of time. Sensors (temperature sensors, load sensors, microphones, and heart rate sensors) are used to detect and keep track of an animal's behaviour. Any anomaly is easily detected, and the farmer will be alerted through messages or other means.	Akbar et al. (2020)
20	MILKING	Animals' management	An IoT system that supports automatic milking in dairy farms. Each cow is equipped with wearable sensors on the neck, tail, or leg. These sensors provide real-time information on the cow's behaviour, activity, health, food consumption, but also its milk production, and fertility management. They can also detect cow diseases such as mastitis or any other disease that can reduce milk production.	Akbar et al. (2020)

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