Cahiers
#Costech

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Impact of Digital Technologies on Farms' Business Models

> #Numéro 6
> Evolution agrotechnique contemporaine
> Working papers
> Agriculture et technologie

To cite this article

Fourati-Jamoussi, Fatma., Dantan, Jérôme., Dubois, Michel J.-F.., Rizzo, Davide. "Impact of Digital Technologies on Farms' Business Models.", 28 February 2023, *Cahiers Costech*, numéro 6.
DOI https://doi.org/10.34746/cahierscostech155 -
URL https://www.costech.utc.fr/CahiersCostech/spip.php?article155

Abstract

Digital Technologies (DT) have an impact on the Business Models (BM) used by farmers. They are used by a growing number of farmers, although not widespread used as this change involves risks and opportunities, both for the inventors and for the farmers. Nevertheless, agricultural world reveals an evolution of Business Models of the last fifty years.
The studies used are qualitative and concern Vitirover and Airinov, two cases developing two technologies: vineyard robots and mapping drones.
The results of this study show that farmers, who develop or use digital tools, are primarily looking for solutions to their concrete problems, whether to create value, enter a market or improve production conditions. Farmers adopting these technologies demonstrate a wide range of skills, a strong desire to learn and a capability to change their models.

Keywords: Agriculture, Business model, Case study, Digital innovation, Start-up

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Outline

Introduction

Three major causal factors can be highlighted in the development and adoption of digital technologies (hereafter DT) in agriculture, at least in developed countries (FAO, 2017). First, the number of farmers decreases, and their average age is growing. Recruitment difficulties and shortages of skilled labour became therefore a recurring problem, easing the way for the emergence of automated equipment. Second, technical innovation is increasingly incentivized to face on the one hand the shortage of land worldwide to feed a fast-growing population, and on the other hand the strong societal demand for sustainable development and agroecological approaches (Karlsson et al., 2019; Kernecker et al., 2019) which favours mechanical solutions instead of chemical ones. Third, population growing is concentrated in urban areas, whereas rural population is nearly everywhere decreasing. Hence, new models to feed the cities should be found.

Altogether, we can point-out that new business models (hereafter BM) of the digital technologies stakeholders for agriculture should be customer oriented. Yet, these technologies are opening the way to new actors who are stepping into the agricultural arena coming from other sectors (Dubois et al., 2019). A fourth factor seems to emerge now: the need of measures, evaluations, and decision-making support shared across the multiple stakeholders involved in the technological development towards agroecology, which can also be described as a need for traceability. Fountas et al., (2015), proposed four types of technological innovation in smart farming: i) recording and mapping technologies, (ii) tractor GPS and connected tools, (iii) apps and tools for farm monitoring and management, and (iv) weeding and harvesting robots.

Based on Kernecker et al. (2019), the designers of digital technologies are more convinced of their benefits, and are confident about long-term technological development. These authors insisted on the need of farmers' perceptions in innovation processes, and of the trends in the application of these technologies to different cropping systems in Europe.

The aim of this paper is to investigate the implication of farmers in digital technologies with a focus on the new BM they created through the use of these tools. On a larger scale, how these new BM can change the actors' interactions and the integration of farmers in the food chain and in the territories? Will they change the farmers' decision-making? We based our reflexion upon a selection of digital technologies recently adopted by French farmers to draw some perspective on the evolution of farming systems and to study the impact of digital technologies on the farmer's business model.

Our research is based on two cases of French companies (Vitirover and Airinov) developing two different digital technologies, vineyard robots and field mapping drones. Section 2 provides a review of the literature on the evolution of Business model in digital farming. Section 3 describes the methodology adopted and the two cases studied to present the digital technologies used by the farmers. Section 4 presents the results, which are discussed in Section 5.

Literature Review: the Business Model Evolution in Digital Farming

During the history of agriculture, farmers have generally been producers. Farming was the basic way of life of the population, not a business. The added value of farmers was just equal to cost of the technical response to their needs. They did most of the artisanal work they needed, even for the modification of their tools. Customer-oriented products were not pure farmers' products. And even the grain trade was a state or wealthy merchant activity.

The beginning of a new type of agriculture, i.e. market and trade oriented, started in the 17th century with Dutch horticulture, in the richest European country. Many new species were cultivated and a plant breeding economy emerged. Flanders and the United Provinces entered a new technical and commercial revolution in agriculture, moving from a producer to a merchant position (Dubois et al., 2019).

The concept of the farmer's BM is not yet obvious, for scientists, farmer's BM has evolved over the last century (Laurent et al., 2003), but it was not the result of explicit and voluntary decisions. Even in the most advanced countries, many barriers still exist today when farmers are asked to consider possible innovations in agricultural BM. They need to understand what a BM means and creation of a new BM required by the innovation, as a result of Sivertsson and Tell (2015), "They have almost always focused on their own farms, not on meeting customer needs".

Zott and Amit (2010), defined the BM “as a network, a system of interdependent activities that helps a firm create value by working with its partners”. According to Karlsson et al. (2019), a traditional BM is defined as a tool composed of a group of elements and relationships that reflect a business to generate profit (Teece, 2010; Osterwalder and Pigneur, 2010). These authors proposed “a new collaborative approach to the development of network-level BMs for sustainability in farm-based biogas production”. Any new firm’s activity focuses first on the customer’s needs and value creation which means developing new BM or changing one or more elements of its BM (Osterwalder et al., 2014; Amit and Zott, 2012). However, even today, most farmers on many European farms focus on producing what is made on the farm, without any conception of the implicit used BM. This is one of the reasons why, once customer oriented, every farmer discovers the concept of BM and starts to imagine new types of products.

Successful digital innovation in agriculture requires an entrepreneurial stance and a good knowledge of what a BM is, especially to develop it as a response to a critical need. Such an approach to BM may seem obvious to young graduates. Indeed, many start-ups in this field are created by young graduates with a strong connection to agriculture, even if they are not directly farmers. Nevertheless, they can attract investment from farmers as customers. Start-up founders and investors related to agriculture should have a good BM adapted to their objectives... but, is this really the case? Digital farming can be expected to necessarily evolve the BM of any farmer, as DT increases the monitoring and anticipating capabilities of farmers, allowing for near real-time measurements of agricultural processes, from pre-sowing soil conditions to harvest. The knowledge could be implicit, the farmer could be unable to explain and justify it, although correctly changed.

In addition, telematics allows for in-depth traceability of each operation until the product is delivered to the market. Investing in information technology means having data to facilitate day-to-day or medium-term decisions. Thus, either the farmer is already aware of the need to move, or he will discover this through the use of these tools, or the new use of these tools for cost reasons could open up new markets (Ayamga et al., 2021; Klauser and Pauschinger, 2021).

Digital technologies are so varied that their relevance to farmers involves different reasons (Kernecker et al., 2019), some of which will be detailed through the examples in the next section. From a general point of view, the use of digital technologies requires precise definition of actions and objectives, as their main characteristic is to measure, evaluate and compare. Some tools simply allow farmers to control their expenses, others to control their amendments, to optimise the use or investment of their materials, to compare and interact with other farmers, or simply to learn. However, it induces both open-mindedness and interest in the purpose of the action. It stimulates the entrepreneurial spirit that is fostered in every farmer.

It is therefore much more interesting to study how an innovation, designed to address a technical problem, can also change the mindset of the farmer.
In fact, we can already see, empirically, types of innovations that can be categorized according to the changes in BM brought about (Dubois et al., 2019). We can find empirically, in connection with direct needs of farmers, 6 major categories of change that can be associated:

1 - Traceability, from the monitoring of the production process to the sale to the consumer, has two major consequences: the knowledge of all the partners along the chain, and the positioning of the final customer in the production choices: the end customer could make burst the BM of the producer (Demestichas et al., 2020).

2 - Digitalized automation provides live information on the situation (for example in livestock farming), which leads to different cost reductions, including salary costs, but also provide services and even health products in exchange for heavier investments. The business plan is similar to that of a heavy industry with long return on investments. So, computation prevision and decision induce an entrepreneurship behaviour attentive to the different levels of competition (Butler et al., 2006).

3 - Robotization radically changes the relationship with work as it also has a direct consequence on the arduousness of manual work and on the value of any farmer work that becomes more reflexive, more strategic. It can do away with repetitive manual work (Bhavana and Bhagwan, 2021; Dutta and Goswami, 2020).

4 - The establishment of platforms can allow the “co-farming”, that means the development of the know-how of the farmer thanks to the new interactions that he has with his partners and with those who participate

in the mutualization of the data and their treatments. Well controlled, it can suppress the negative black box effect (see below). The association #cofarming in France brings together a few dozen agricultural technology start-ups (https://cofarming.info/).

5 - The storage and processing of big data (such as Hadoop HDFS and MapReduce) would never be done by the farmer; this leads to new partnerships and negotiation about sharing the value of data, production of data, and so on (Bronson and Knezevic, 2016).

6 - Full control of environmental data; nutrients and water, temperature and light are already proposed by other start-ups (e.g., Agricool, Myfood). This can lead to a purely industrial BM, which can be identical to the production of a classic industrial consumer object. Nevertheless, in more traditional agricultural conditions, i.e. the main part of the land devoted to agriculture, the sale of ecosystem services is easier from evidence provided by the digital tracking of activities (Kulbacki et al., 2018).

Methodology

We focused on French agriculture. A recent report has been published to guide the French strategy in the development of artificial intelligence called for exploiting DT to facilitate the development of new BMs in agriculture, in order to support the emergence of French and European “agritech champions” (Villani, 2018). Consequently, we wanted to investigate the BMs of some of the French digital technology players.

Data collection

The analysis of start-ups in farming reveals three main motivations for technological innovations: create value, enter a new market and improving production conditions. If theses motivations meet environmental requirements, and if these last requirements are compensated by increased funding, all is now ready for a larger movement towards DT.

The qualitative studies were based on interviews with the sales manager of Airinov in 2015 (Dubois, Sauvée, 2016), who is also a farmer, and with the co-founders of Vitirover in 2017 (Caroux et al., 2018). They are complemented by the current development, until 2020, of these two firms.

Each interview lasted around three hours, and was focused on four themes: i) the presentation of the firm and/or start-up, ii) the technology functionalities, iii) the BM of the firm and/or start-up and iv) the impact of this technology on farmer's BM.

The interviews were transcribed and analysed qualitatively, as detailed below, according to the following foci:
- a "product" focus: the lack of technical response to a problem found in the field leads farmers to invent and propose a solution (e.g., Vitirover robot or Airinov drone);
– a "market" focus: the identification of a niche market reduces the dependence of the farm on its market and leads farmers to develop crops for which market opportunities are not managed by storage organizations. This is typically a development that can perform a farmer who is already market oriented, because of DT development or other type of technical innovation.

Two Case Studies

We present the two selected case studies that can be considered representative of the application of robots and drones in agriculture (Yin, 1994):

Vitirover presentation: Château Coutet's context in Saint-Emilion

In the Saint-Emilion region of Bordeaux, vines are the dominant plantation. It was at Château de Coutet, which has been closely linked to the David Beaulieu family for at least four centuries, on a vineyard whose accounts have been kept since 1809, that the Vitirover robot was designed. Growing methods have changed a little since then, but it has remained organic from the start. Yields are low, but the Saint Emilion wine is well appreciated and well valued. The vineyard is still used as a study ground for the Vitirover solar robot.

The Vitirover robot was designed to deal with the technical problem of mechanical weeding and the desire not to use herbicides, the idea of weeding by autonomous robots has gradually developed. In 2011, the meeting of two committed people with very different backgrounds led to the development of a high-tech innovation in the wine sector, and then to its extension to other fields such as rail transport or energy production... The robots and services developed by Vitirover provide innovative solutions for soil maintenance and weed control.

Airinov presentation

Airinov was a young company founded by a farmer's child and two engineers. It was based on the use of sensors installed on drones to map fields and offer decision support to farmers and seed companies. As the cost of drones and sensors decreased, the use of drones expanded (e.g. spraying, biocontrol dropping, cover crop weeding) and offered more competitive and adaptive services to farmers.

Airinov has been the leader in drones in agriculture for 9 years (2010-2019) and has provided variable rate application maps from drone field surveys. Despite its rapid growth, its association with Parrot since 2015 and its collaborations with INRA researchers to enrich agronomic references, Airinov ceased its activities in July 2019. The reasons for this event are explained below. We will also discuss the relationships and impacts of this event on the business models of its various actors.

Findings

For each case study, we present firstly the technology functionalities; secondly, we detail the BM of the company or the start-up and finally, we analyse their impact on farmer's BM.

Vitirover Case Study

Mower-robot functionalities

The Vitirover robot was designed as an answer to the difficulties of mechanical weeding in the vineyard using the plow cutter. This tillage implementation, carried by a tractor, is used to remove soil thrown under the row in the fall. Its use is often essential during the grow of plant cover under and between rows, because manual work is too expensive. However, the slightest error leads to the uprooting of a stalk, and moreover plowing does not protect the soil. It explains the great success in viticulture of glyphosate use. In the absence of glyphosate, either you go back to the tractor with a ripper, or you have to invent something new.

The idea for a robot arose while passing through a sloping plot. The tractor, which passes close to each side, injures or touches many vines.

The power of the tractor does not make it possible to feel that a plant is torn off, a problem which did not exist with the horse which felt the resistance and stopped. On sloping ground, the ripper is very delicate to handle. In addition, to both avoid the competition of weeds with the vines and protect the soil, especially on slopes, the ideal would be to keep a soil covered with mown grass. We had to find a self-contained tool that constantly reduces the height of the grass at a low energy cost, while remaining very delicate with the vines. It was also necessary to be able to memorize passages and centralize information, in order to manage the succession of passages. This led to the idea of a very small robot machine.

Vitirover started raising funds for the design of his mower-robot. The designers have verified that there are no technological constraints like GPS and photovoltaic panels. It is a small machine that moves on agricultural land, under and between vine plants, able to orient itself and avoid obstacles... From there, the designers have started working on a second generation that observes and sends its information to the cloud, with photos of the vine, leaves, bunches.

“The Vitirover invention tends towards a design of necessity, it is imposed by the agronomy of the vine. Today, the wine growers have become aware and are determined..., to reduce the use of glyphosate and other herbicides.” Co-founder of Vitirover.

The Business Model of Vitirover

The BM of Vitirover is built on the use of a robot for two hectares, so 50 robots for an area of 100 hectares. The co-founder of Vitirover agrees to the result: “You don’t have equipment to buy. We make a commitment of result”. Vitirover proposed a service which costs around 2,000 euros per hectare and per year. The only problem of the client is related to specify the maximum height of his grass. The payment of the machine, the after-sales service, the guarantee and the maintenance are supported by Vitirover.

“Our quest has been to market and have our early adopters - that is, find the people who are innovators in this viticulture field.” Co-founder of Vitirover.

These early adopters invest on this invention because they understood that it could lead to their communication in articles in the regional or specialized press, cameras in their fields ... the major impact of this invention on the farmer's BM is to improve their image to its consumers by reducing or removing the glyphosate. But also, it changes the cost: less fuel, less use of tractor, and may be no more tractor. It is a low energy solution.

The aim of Vitirover is to make an intellectual revolution with its customers. Its strategy is projected over five to ten years, with simulation steps for virtual prototypes to insert this virtual prototype in a virtualized vine, and to optimize the number of robots that will be put on the surface.

"When we say a vine robot for two hectares, we're not yet completely sure, we're oscillating between one, two and three hectares for a robot. To have a clear speech - it's hard enough to explain - our goal is to optimize all that." Co-founder of Vitirover.

Vineyards all around the world are interested. The cost of Vitirover robot is higher than glyphosate cost, but it avoids to use or even to have a tractor. And Vitirover's BM leads to a new profession: the robot shepherd as employee of Vitirover. The farmer has just to buy a service based on commitment and, depending on the situation, choices and costs can be different.

The mower-robot large impact on the Farmer's and other customer's BM

As the robot mower is small and versatile, it can be used in new and unexpected situations. It is suitable for all types of tree production (all citrus fruits, apricots, cherries, apples, pears, nuts and hazelnuts, cashew nuts, bananas, poplars, etc.). It is useful for high-voltage electrical substations with precise and safe control of vegetation or railway edges for its extreme precision and efficiency, airport lawns and now for photovoltaic farms. It will certainly fit in with corporate lawns and gardens.

For customers, it is a simple service. But expanding the range of uses could allow Vitirover to reduce costs and therefore better adapt to its customers to provide better opportunities for farmers.
For many farmers, this innovation could reduce the use of large machines and therefore the investment, fuel and labour costs.

It is easy to forecast new applications: after making it possible to do without glyphosate and/or tractors, the Vitirover robot will provide information and visuals (on-board camera) to have a very detailed knowledge of the development of diseases. By being permanently in the plots and on the basis of 4 to 5 years of plot history, the winegrowers/farmers will be able to treat in a more preventive way on smaller surfaces, with more gentleness and especially at an earlier stage. This will result in a significant reduction in the use of plant protection products. The company Vitirover could even envisage carrying out the micro-spraying by robots and climbing slopes of 40 degrees.

Airinov Case Study

The functionalities of drones provided by Airinov

The challenge is to use sensors on board drones to be able to map fields. The drone will map the entire plot with great precision, in wavelengths invisible to humans, in order to detect intra-plot spatial heterogeneities and to optimize the nitrogen supply in the treated plots.

“This tool is fully automatic and surveys the parcels in a way that is not humanly controlled. The piloting is automatic. We program the drone before take-off.” Sales manager of Airinov.

The procedure for acquiring data by the drone is as follows: the farmer requested his need for a drone from Airinov distributors. The latter has prepared the order and sends it with an “Agridroniste” who is responsible for flying the drones. The recovery of spatial data is carried out by Airinov. These data are processed by agronomic models developed by INRA. The distributor collects the processed data and transmits it to his customer, the farmer, in the form of advice.

“Once the acquisition of the images is complete, the operator will transmit these flight data, i.e. photos, to Airinov for processing. In the first place, it is a question of reconstructing the maps. Then, they will be analysed according to INRA agronomic models which are physical models. These models provide physical variables such as chlorophyll levels or leaf density.” Sales manager of Airinov.

The drone allows to better distribute the nitrogen in the whole field. The farmer pulls the yield and the quality upwards and observes the yield maps become less and less heterogeneous.

The Business Model of Airinov

At first, drones were intended for the French market. Airinov kept the ownership of the drones and sold the service (between 2010-2019): data entries into drones (programming), data processing from models obtained in partnership with INRA, etc.

A change of Business Model

Then, at the incentive of Parrot, Airinov changed its strategy for its business model: the objective was to sell drones equipped with a new consumer sensor to farmers. The idea was to use enough general remote sensing and agronomic models to deploy drones around the world. From an agronomic point of view, producing efficient agronomic models suitable for all countries around the world is very complex and time-consuming; the models are often varied even within the same country. The agronomic models therefore had to be transposed to the new sensor used, which requires significant adaptation work, otherwise it will be inefficient and less interesting for customers.

Furthermore, deploying this business model on an international scale had a significant financial cost (communication, deployment of local branches). The business model aimed at selling drones suitable for agriculture around the world has not been successful because of these constraints.

Agricultural incomes highly dependent on both the economic situation and the weather

The income and therefore the investment capacity of farmers is directly linked to the weather. For example, there were a bad situation for farmers in 2016: low yield in Europe combined with high yields in the rest of the world, leading to lower prices in the agricultural market. As farmers no longer have the means to invest in decision support systems, the expected growth of Airinov sales has not been achieved.

In addition, under “normal” conditions, some farmers already obtain good yields with their usual crop production management practices, which does not encourage them to invest massively in new technologies such as remote sensing.

Such a dependence on the weather of the agricultural world means that the growth of this technology could not achieve the expected objectives, which could even lead to mishaps.

The drone impact on the Farmer's BM

Many priorities to manage for farmers

Remote sensing requires programming and drone flights during key moments of a crop campaign to be effective. During these times, farmers are usually very busy and have little time.

In a business model where farmers equip themselves and then organize their flights themselves, even if piloting a drone seems fun, farmers' priorities must be considered. For instance, a certain amount of rain following the application of nitrogen fertilizer is necessary to be valued as well as possible.

The weather is therefore of particular importance: if, one day, the weather is fine and rain is forecast for the next day, farmers will have to program a flight with the drone and then spray nitrogen in connection with the modulation map obtained. If it takes too long to configure and pilot their drone, farmers will spray nitrogen directly on their fields without modulation, so as not to miss the rainy episode. Drones must therefore work the first time, in "plug and play" mode, otherwise they may make farmers reluctant to use such equipment, which requires adaptation time.

Farmers are looking primarily for a service, i.e to obtain directly modulation data to be integrated directly into their spreading equipment, to reduce the supplied quantity of nitrogen while maintaining or even increasing the final yield and therefore the production value.

An opportunity for cooperatives

While farmers may be reluctant to configure and pilot a drone, cooperatives can do well by offering modulation map services from sensors installed on drones. In terms of communication, drones are more an opportunity than satellites to highlight the modernization of agriculture, drone being more visual and fun. Specially trained technicians from cooperatives can go directly to farms to fly a drone and next integrate modulation maps into the agricultural equipment. This is a service for which farmer should not have to solve any problem related with (e.g. IT problems).

Impacts of mapping on revenues and costs

The sales manager of Airinov estimated the revenue gain to be around 5% (around € 50) per hectare. He gives the example of his farm, with 70 hectares of wheat. “The mapping and control of modulation could bring an additional gain of € 3,500 in turnover”. The gain is all the more interesting when, thanks to the modulation, the protein level is improved, thus switching from a feed wheat to a milling wheat, which increases the selling price of crops.

From a regulatory point of view, in some regions, it is interesting to use modulation tools to uncap nitrogen input and to justify an additional supply when nitrogen is the limiting factor (e.g. in Santerrre). Conversely, in some regions such as Poitou, where the yield potential is limited by something other than nitrogen, the use of a modulation tool is of less interest.
In terms of cost, it is important for farmers to know whether their agricultural equipment is already operational for modulation: indeed, the additional investment to do automatic modulation is expensive (more than € 10,000). Indeed, “the full modulation investment (fertilizer seed drill) associated with GPS is about 1/5 of the investment (i.e. 5 years before making money). The management of the last fertilizer application on wheat seemed most relevant.
We thought that this could improve the protein level, which might be the case in some years”, Sales manager of Airinov. To these costs (approximately € 15,000), we must add the cost of either purchasing the drone (€ 5,000) or purchasing the service.

Uncertain weather-related gains

However, although costs are known, gains are uncertain. This fact is illustrated by the two events described below:
– A catastrophic year like 2016 significantly reduced the income of farmers, which severely affected their investment possibilities. Consequently, farmers had other priorities besides buying decision support tools; they saved their money to buy seeds and fertilizers for the

following year.
– On the contrary, during more favourable years like in 2017 and 2018, the gain may not be verified because the quality of the wheat obtained was already sufficient: “the two years which followed were characterized by a very dry month of June. and sunny, therefore with a protein level already sufficient to obtain attractive prices”.

The cost-effectiveness of such a drone imagery-based decision support system is subject to uncertainties such as weather events as well as the worldwide economic situation. Companies offering fertiliser crop management tools performed poorly during the catastrophic year of 2016, leading farmers to other priorities.

Discussion and Implications

We highlighted in the literature review that some digital technologies (drones and robots) in farming systems are adopted when the farmers perceived the improvement of agricultural outputs (Dutta and Goswami, 2020; Bhavana and Bhagwan, 2021). The two case studies showed that we need: i) to connect the BM of the technology provider (Vitirover and Airinov) and the BM of the farmer, not just the impact of the technologies on the BM of the end-user. ii) to consider that the strategies of the providers of these technologies can impact both their survival in the market and the success or failure of the adoption of these technologies.

Connecting the BM of the digital technology supplier and the farmer’s BM

The farmers involved in digital innovations are entrepreneurial and innovative without being solely fascinated by their technical issues. The winners in these situations are often well-trained young people who have acquired an approach that combines technical skills with an openness to the market and to end-customers. Most, but not all, of them are children of farmers. They can combine a sense of the land with an interest in technical development and business skills. They are also more open to different ways of doing things and have generally adopted more market-oriented approaches: this leads to new and analysable business models. Some have done engineering schools, others business schools (Ritz et al., 2019).

They believe that progress is possible yet. They discovered agricultural problems and integrated the repetitive aspects of the work, its arduousness, and the complexity of the overall operations of the farm. Moreover, they have often acquired through their training that the customers should be at the heart of their concerns.

Although, until the first industrial revolution, agricultural innovations were bottom-up innovations, for the last two centuries, most of them were the result of top-down incentives (fertilizers, phytosanitary products, herbicides, plant breeding, tractors and machines, new rotations). With the new innovative farmers, a change is coming. They come from the ground up and then expand, so they are directly linked to the land and types of production, while being driven by customer demands. This leads to important choices, specific to places, productions and markets near or far. In fact, these farms are often highly differentiated.

DT can in fact be imposed to the farmer (e.g. tractor evolution) and allow him to evolve. Nevertheless, the use of data and the use of the outdoor black box with the farm can put the farmer in a position of weakness and / or submission that may cause the installation of the technology to fail. A “black box effect” can be discussed. Guchet (2016) suggests that Airinov model seems to lead to a form of “expropriation of the farmer’s own knowledge”. He asked a question about “the risk of a marginalization of the farmer” in the whole of the agrotechnical knowledge production system. In other words, all these data acquisition and processing systems form a black box in which the farmer may have to ask himself about his position and profit following the drone adoption. This analysis could be a part of explanation of final Airinov failure.
As Airinov’s sales manager said, “can we say that start-ups offering fertiliser management tools are changing the farmer’s business model and vice versa? Indeed, the farmer’s business model, and especially his economic accidents, influence the start-up”.

Finally, farmers are looking for a service, to obtain modulation data directly that they can easily integrate into their equipment. The constraints and requirements of the farming profession are above all guided by the weather, which means that any service or equipment offer must be both reactive and reliable.

Comparison between the two firms’ strategies

Vitirover opted for DT that are easily achievable, easily evaluated and of course property of the farmer. Until now Vitirover is just selling a service, but as it will evolve as a sensor producing data, the question will arise. If the data is processed in the first place by the farmer, it may be consistent with the know-how.

In the second place, the contribution of DT must be financially easy to evaluate and of course must show profitable within a reasonable time. The use of Vitirover technology has a very positive image impact, could reduce costs and can open new markets. Airinov drone had only one application, on a difficult agronomic problem. Finally, it is difficult to compute the advantages as it depends strongly on yields, on daily weather, although its use must be planned. For some problems, DT could be too expensive compared to the advantages although the subject must be qualified: there are many uses of DT in the aim to solve one problem.

In another place, it seems reasonable that for the production with higher revenue and margin per hectare, but with need of a lot of human work, the relative cost of a drone or a robot could be less a problem. Vineyard, but also vegetable growers, has a much higher production value per ha than wheat, rapeseed or beet. This is also a problem Airinov had to face, and its strategy change has increased the problem.

The development of DT can lead to the need for a new agronomy. It could here be an opposite effect, a positive one, than the black box effect. For example, Vitirover offers the possibility to measure the effect of grass turf at different heights and decide on the effect of grass height on yields, the protection against certain diseases and the protection against drought. Thanks to some other innovations like localized weather stations, it will be possible to evaluate the impact of the actions according to the real conditions. Work organisation can be radically changed.
Finally, the strategy of Airinov made it very sensitive to open competition. The cessation of Airinov activity can also be due to such a competition. DJI Technology Co. filed two patents between 2018 and 2019 on agricultural drones and conquered the French market through its commercial partnership with Delair-Tech, which is selling drones for the industrial sector and wants to penetrate the agricultural market. Specialization on cartography was also in competition with GPS, in permanent improvement. Farmers could find easily the GPS solution and have difficulty to find their interest in Airinov’s BM in terms of data acquisition and processing also in competition with other technologies or actors.

Since the foundation of Arinov, many competing offerings have developed in parallel.
For example, Agroptimize had a different strategy. Indeed, it is a university spinoff created by the association of the University of Liège (ULiège), the Luxembourg Institute of Science and Technology (List) and the French company Wanaka. It relies on many pilot farms in France and Belgium, but also in other European countries. It offers services ranging from yield assessment, damage analysis (insurance), decision support tools (sowing, nutrition), monitoring tools (weather), etc. derived from remote sensing vectors such as satellites (for general purpose) and drones (for more specific needs).

In addition, the offer based on satellite data has evolved considerably: Farmstar is a service allowing farmers to observe their crops over the entire cycle in order to optimize crop management in their plots. It includes a nitrogen modulation service, the import of modulation maps into the agricultural equipment. Farmstar has benefited from improved satellite imagery in recent years.

Then, the sentinel-2 satellite network, deployed from 2015, provides access to raw high-resolution hyper-spectral imagery data. Satellite raw data are free of charge while drone raw data have a cost. In both cases, it is then necessary to process data models and make the results available thanks to software. Note that from satellites were quickly exploited by start-ups as well as by global companies.

Regarding competition between drones and satellites, the sales manager of Airinov acknowledged that "these technologies compete. Satellites cannot achieve accuracies greater than ten meters, while the drone's sensor have pixels of 15 cm. On the scale of agricultural plots and current spreading tools, which are more than 30 meters, 15 cm or ten meters are approximately the same ... For vegetable growers, as the plots are small enough so that they need more accuracy, drones regain their competitiveness. High income per area unit with more limited areas are needed."

Conclusion: the Consequences for Farmers in the Future

We can expect many changes in agriculture through DT, both in terms of farming and agricultural territories. It could also create disparities, or even inequalities, very strong between types of agriculture and entrepreneurial behaviours of the farmers.

One can imagine, in some cases, that there will be a decrease in costs. Simplification of decision-making processes and any acceleration of data acquisition means lower staff and input costs. This usually leads to a gain in productivity.

There is no identity between robotization on one side and obtaining and processing data on the other. Even though robots can become carriers of sensors, it is possible to set up data entry systems without further robotization. It may depend on the productions. The economic computation shows that for polyculture-livestock farms, for example, the very strong robotization concerns first medium-sized operations that seeks to limit the number of employees. On the other hand, large farms (500 h or more) have an interest in favouring the wage earner and bet on the digital without investing in robotization.

DT favour any BM that puts the farmer in touch with his market: “from seed to cooked dish”. It should be noted that this will probably be the case also for processing directly on the farm, since traceability will be required to produce energy. Where it is less intuitive, and requires more computations, i.e. in agroecology development, DT can play a valuable part, through precision farming. The data can play the role of proof of action and impacts of actions.

DT are a set of technological clusters that can promote entrepreneurship. This will increase the rate of farmers becoming real entrepreneurs. As we have seen earlier, certain ways of using technology can deprive farmers of their freedom of decision. One can imagine that a part of agriculture could fall into a model of servitude where the farmer becomes a mere executor of decisions taken elsewhere. But the model built on an innovator and dynamic behaviour of the farmer seems much better.

DT, in such a way, could open possibilities, with a lot of different choices and a lot of different ways to be a farmer. Among possibilities, we can consider large farms with little robotization versus highly robotic family farms; direct connection to the market through mutualization, or from seed to cooked dishes with transformation on the farm; energy production on the farm; use of artificial intelligence for database analysis or data transfer to external groups. There are many possibilities between precision agriculture and agroecology. “Geek mindset”, i.e. all that becomes possible must be done, or “digital phobia” which prefers not to play with all these new tools cannot help for any suitable decision. Technical and BM analysis should be performed. Not all DT is good neither for business nor for human development.

The BM of Airinov has evolved since its acquisition by Parrot in 2015: from deploying services to French farmers, Airinov has moved on to an international development strategy aimed at selling inexpensive drones to farmers all over the world.
It needed a lot of work to significantly adapt the existing agronomic models. Internationalization had also huge commercial and communication costs.

The sales manager of Airinov was constrained by both weather events in Europe and global low prices for field crops. Finally, the advent of satellite imagery competed with drones on field crops, thus reducing the market for sensors installed on drones that are too expensive.
Kernecker et al. (2019) suggested in their study that differences related to agricultural structures and farming systems across Europe need to be considered if digital technologies development and adoption by farmers should be improved.

Acknowledgements

We are grateful for the support of the chaire Agro-Machinisme et Nouvelles Technologies, backed by UniLaSalle with the financial support from the Michelin Corporate Foundation, AGCO Massey-Ferguson, Kuhn, the Hauts-de-France Regional Council and the European Regional Development Fund (ERDF) and The chaire of Management of Risk in Agriculture, backed by UniLaSalle with financial support of Groupama insurance.

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