Framework for the Digital Transformation of the Agricultural Ecosystem

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J. Dörr and M. Nachtmann (eds.), *Handbook Digital Farming*,
https://doi.org/10.1007/978-3-662-64378-5_2

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2.1 From Farm to Fork and Back: History and Roadmap of Digital Farming

Carsten Gerhardt

Abstract

Global supply of agricultural products surpasses demand. This puts the industry under permanent price pressure. Digital Farming as a mean to improve yields and become more cost-effective has entered the market around 2010. It will continue to be applied to a steadily increasing fraction of the global farmland. This will heavily impact the agricultural input industry, which will transition from a product to a service provider. Plus, digital will change the face of farming, as it allows to move away from ever bigger machinery to small, autonomous swarm robots. Ultimately, digital in agriculture is a key enabler for the transition to a bio-economy where farmland will provide inputs to a variety of industries, well beyond today's food and feed.

2.1.1 Introduction

Agriculture globally has been characterized by large production increases of the last decades to feed a growing population. Yield increases and additional farming land have been driving this overall production increase. The former could be achieved due to a very professional Ag input industry, providing high-yielding seed, fertilizer and AgChemicals. The latter often has come at the expense of turning natural habitats like rainforest into farmland (see ► Sect. 1.4). Both ultimately have led to environmental degradation and are not sustainable. Monoculture, loss of biodiversity and soil degradation characterize agriculture in large parts of the world in 2020. A further production increase cannot be achieved by the means of the past. Great hopes and expectations put into novel technologies like second- and third-generation genetically modified seeds or biologicals for crop protection have not materialized.

At the same time, the industry now is under price pressure. The farm-level prices of agricultural commodities corrected for inflation mostly have declined over the last centuries.

The highly consolidated farm input providers had nicely profitable businesses and benefited from an overall market growth for the last decades—it was a tide that lifted all boats. However, this trend began to slow down around 2015.

Digital will drastically change agriculture moving forward. Digital Farming has been emerging after 2010 as a possible solution to improve cost structures, increase yield, and at the same time lower the environmental footprint of agriculture. Digital means can increase the efficiency and effectiveness of the existing processes before, on and after the farm. This increases production at improved cost positions and optimizes quality. Furthermore, digital may provide a means to better communicate quality features of the agricultural products through tracking and tracing technologies, ultimately realizing a better product price at the retail level. Digitally operated machinery in the field will totally change the face of farming in the long term.

Finally, in an economy that is turning more and more circular (Circular Economy), agriculture will play an important role: on the one hand as provider of bio-based feedstock, and on the other hand as off-taker of post-consumer materials such as sludge, compostable organic waste and biodegradable plastics. For the management of these circles, digital support will also be of vital importance.

2.1.2 View on the Agriculture Industry Overall

The agriculture sector from farm input providers over distributors, farmers, processors down to retail as a whole has been growing steadily and in parts profitably for decades, driven by two fundamental demand drivers (see Fig. 2.1). Population increase, on the one hand, is going from 5 bn in 1990 to almost 8 bn in 2020 and is forecasted to near 10 bn in 2050. Along with the increase in number of people went an increase in calorie consumption on the other hand very much triggered by a heightened meat consumption. Given the limitation of land, increased production could only be achieved by the help of a professional seed and AgChemical industry. The crop protection market alone has almost tripled from 1990 to 2020, from slightly over 20 bn USD to almost 60 bn USD. A similar development could be observed in the seed industry, both in genetically modified and conventional seeds. Higher yielding and seeds better adapted to regional specifics were the main productivity driver besides improved agronomic practices.

But there are imperfections in the "conventional story" of lasting industry growth. As early as 2015, the OECD long-term agriculture outlooks started to paint a bleaker picture of production growth, with annual growth rates for key commodities like wheat, soybean, corn or poultry meat decreasing from historical values between 2–4% to almost half of that (see Fig. 2.2). Nominal commodity prices were forecast to stay stable or even decrease. This anticipated price development is very much in line with an overall rather weak price development of agricultural commodities in the past. Except for variations that were most likely caused by speculation, the overall price increase, for example, for wheat has barely increased by 30% from 1990 to 2020. If adjusted for inflation, it has even decreased, resembling a trend that could be observed during the complete last century. Other, non-agricultural commodities have shown a substantial price increase in the same period. The copper price from 1990 to 2020, for example, has risen almost 300%.

Besides the challenging growth and price outlook, there are additional challenges for the agriculture industry. Multiple

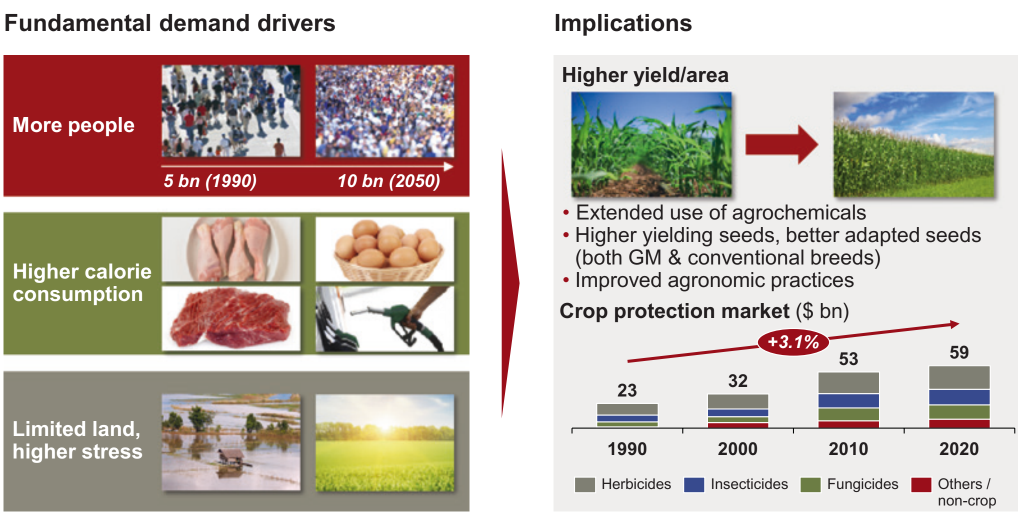

Fig. 2.1 Fundamental demand drivers provided a growth story to the Ag input providers

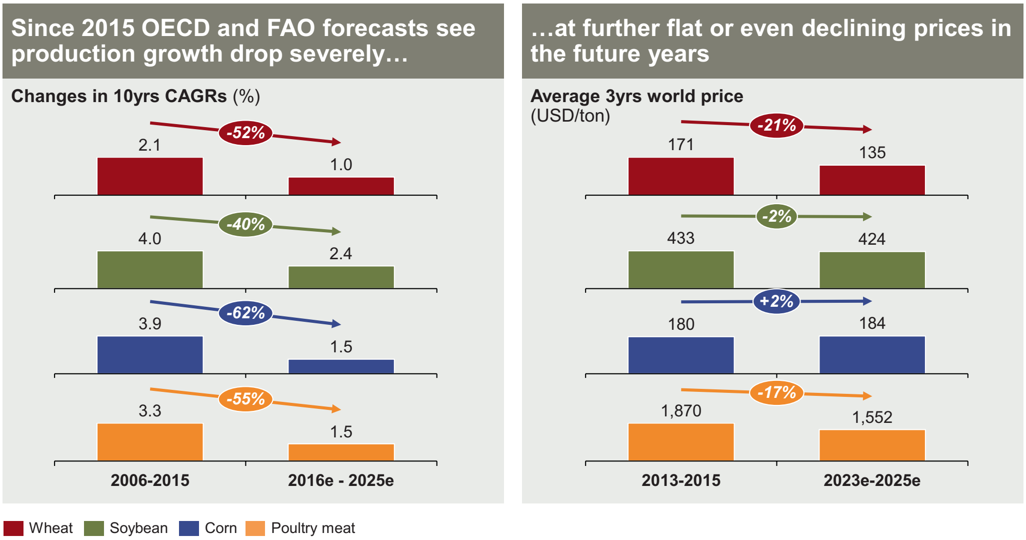

Fig. 2.2 OECD/FAO forecasts since 2015 forecast declining growth rates and flat prices

trends are superimposing and affecting the industry's development.

Many technologies are reaching their limits. This can be seen from the increase of resistances in crop protection or chemical substances backfiring on crop yield. Also, soil fertility is being reduced in many global geographies due to biodegradation.

Especially in mature markets social scrutiny is increasingly turning against modern intensive farming. A significant part of consumers is against GMO or the conventional high-input agriculture. Percentages differ strongly between regions, from low double-digit percentage in the USA to almost two-thirds of consumers in France. Ultimately this consumer skepticism will result in further tightened secondary standards that drive down the use of AgChemicals and regulatory approvals and registrations that will be much harder to obtain going forward.

Then, there are many innovations with a disruption potential: They can broadly be structured by whether they impact demand or supply and their degree of certainty (see Fig. 2.3). The latter is ranging from already existing trends like novel traits, farm consolidation, extension of cropland or no-till farming over already known-trends that are currently materializing like vertical farming to "unknowns" like space farming. Specifically, in the area of crop protection, robotics and automation are likely to further replace today's crop protection technologies. One major trend that will heavily impact the whole agriculture value chain is alternative proteins/artificial meat. Having been known for several years now, 2019 was the year of successful market entry. Next to plant-based and insect-based meat alternatives, cultured meat can clearly be seen to be evolving. All these new products have the potential to not only disrupt the multi-billion dollar global meat industry but also the whole value chain due to the impact on feed demand, especially in corn and soy. Our research shows that in 20 years from 2020 onwards less than half of global meat consumption will still come from conventional meat sources. The rest will be novel vegan meat replacements and cultured meat [GSZ+19].

It is against the above-described background of a challenged, rapidly changing industry that we now take a look at the development of "Digital" in agriculture.

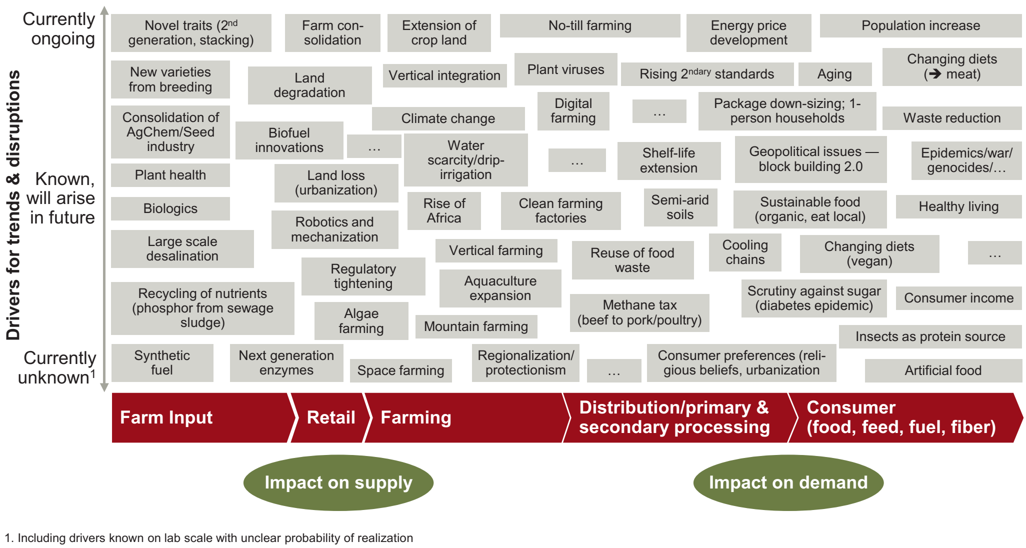

Fig. 2.3 Disruptive trends in the industry

2.1.3 The Roots of Digital Farming

For the purpose of this section, we define Digital Farming as all farming methods that use the means of digital to optimize agriculture, which is in line with the definition in this book. We consider optimized agronomical advice, based on big data insights generated from a multitude of sources as the most important building block.

Hence, it is much more than just digitizing individual parts of the value chain, like e.g., digital sales channels or e-commerce. Precision farming as the ability to very precisely plant, fertilize, spray, and harvest is also only one component of Digital Farming. It constitutes an important enabler for Digital Farming, though. Terms like Smart Farming or Farming 4.0 in our view can be used as synonyms for Digital Farming.

Farming always has been at the forefront of innovation, from a variety of mechanization methods in the eighteenth century to the introduction of the steam engine. Tractors with steam engines were in use as early as from the 1870s on soils that could bear the weight. The adoption and early introduction of novel technologies not only has tremendously helped increase yields per hectare but also brought down labor needs in the field. One farmer today can harvest in excess of 100 hectares. Work productivity in the field has increased by a factor of well over 100 in the last century.

Not surprisingly, farming was an area of our economy that embraced "digital" very early. Already at the beginning of the century increasingly more equipment parts got digital features (combines, tractors, etc.). For many years, this was primarily to better capture information on performance indicators like product use or yield by the farmers. But the basic necessary building blocks to arrive at digital farming solutions were present (see Fig. 2.4).

Digital Farming soon has been identified as an attractive market where all prerequisites were given to realize a substantial value potential. This starts with the technical feasibility. Data collection devices on the equipment have been in place since the start of the century in the form of cameras, sensors as standard equipment for many new combines and tractors with more than 200 horse power.

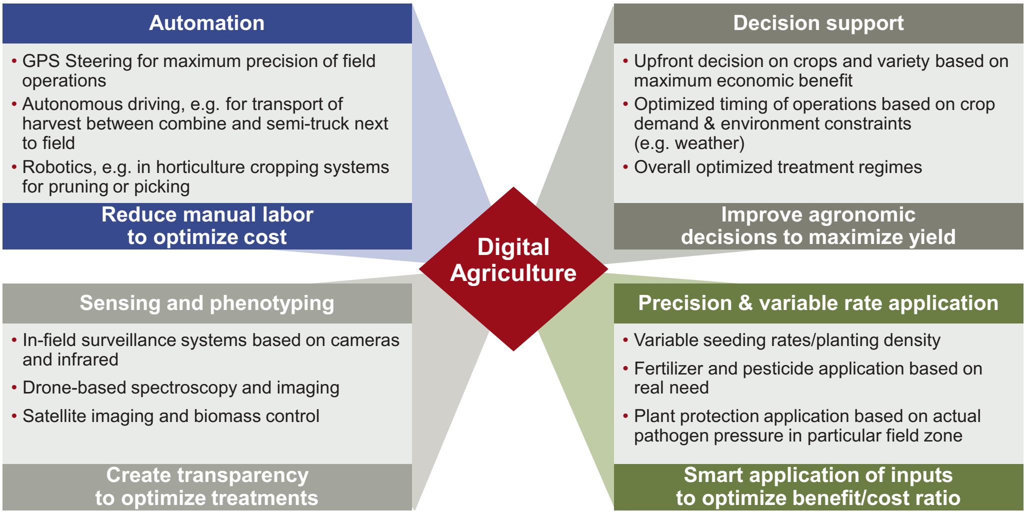

Fig. 2.4 Technological elements of Digital Farming—need to be brought together

The potential to increase yield could be taken as a given. In project work with leading agricultural chemistry and seed companies globally broad acre crops like cereals, corn and soy were identified to have a yield increase potential of at least 15–25%, with the biggest levers for yield increase being seed variety, fertilizer and crop protection. With the generational change already in 2015 some 20–30% of growers were identified to be willing to apply Digital Farming in Europe, a number expected to double by 2024. The estimated total value creation potential is estimated to reach up to 20 bn p.a. in the broad acre crops in the decade of 2020. This translates into a value capture potential of up to 7bn USD p.a. for the service providers at a 30/70 profit split between industry and the farmers. In the long term, i.e., beyond 2040, the added value of a crop production globally increased by 25% and more is in the order of magnitude of 200 bn €.

Many players from a variety of industries went after this value. Seed and crop protection companies, distributors and equipment manufactures saw the potential first. Digital farming start-ups sensed the opportunity to disrupt an established market as well as IT & data analytics companies. They could be well differentiated by the range of their offering and the level they were willing to put skin into the game. The offering ranged from single famer job steps over multiple job steps in crop management to a comprehensive crop farm management offering. Level of engagement spread from simply providing information or providing specific assessments over tailored advice including guidance to implementation/application to assurance of the targeted benefit and sharing risk with the famer. So far, no provider could win with a comprehensive crop farm management offering with assurance of the benefit. Most solutions are confined to several job steps and giving tailored advice.

At first, a plethora of Farm Management and Information Systems (FMIS) emerged, seeking to support the farmer in managing his plots and internal processes. Other systems were developed to better manage singular dimensions relevant to the farmer, e.g., weather events.

The first landmark in a true development towards Digital Farming that provides a comprehensive recommendation scheme was set by the acquisition of Climate Corp by Monsanto in 2013 for 1 bn USD. Climate Corporation had been one of the first companies aiming at developing holistic advisory tools for farmers along the crop cycle. Originally founded in 2006 as “Weather Bill” the company had initially focused on providing weather insurance to farmers but also other industries dependent on weather effects, like ski resorts or large event providers. Since 2010, the pure focus was on agriculture with the Total Weather Insurance product coming out in late 2010 on the large row crops corn and soy. Over the next years, Climate Corp moved out of the insurance business and around the time of its acquisition by Monsanto targeted digitally supported decision making for the farmer with Climate Basic and Climate Pro. Those developed into integrated service offerings with a focus on nitrogen management and field health on a per field level, later accordingly re-branded as Climate FieldView. Striving to gain more focus on digital advisory Climate Corp in 2015 intended to sell its hardware activities in Precision Planting LLC to John Deere. The deal was ultimately closed with AGCO in 2017 due to anti-trust considerations.

With Bayer Crop Science stepping on stage with its digital farming offering xarvio at the mid of the decade, this trend towards holistic recommendations from seed selection over fertilization/nutrition to crop protection was expedited.

The holistic digital farming offerings focus on the complete crop cycle from planning over planting, nurturing, crop protection to harvesting (see Fig. 2.5). They cover optimized in-field operations, a decision-making system and the capturing and processing of data from the field. Those range from historical field data over soil analytics to exact plant nutrition information, pathogen occurrence to weather information. Source can both be proprietary field data or publicly provided data of the respective plots.

These input data—historical and current—will be fed into a decision-making system that combines agronomic understanding with artificial intelligence and algorithms and modeling tools to provide recommendations for all steps of the crop

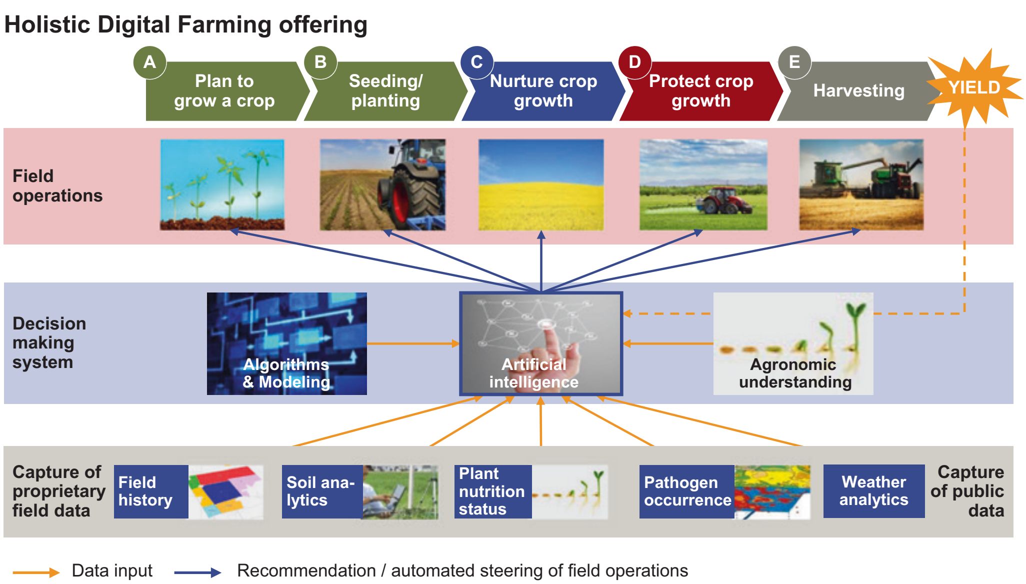

Fig. 2.5 Holistic digital farming offering

cycle. It is important to note that the power of the system results from the breadth of data it is supplied with. Data from local fields, combined with data from other fields in comparable soil and climate conditions, plus research and development data from the farm input providers and distributors. Several other players from a variety of industries (equipment producers, distributors, tech companies, etc.) also began to increasingly invest in the area and consolidated smaller companies, e.g., satellite imagery providers into their offerings—those companies to a large extent had their origins as consulting and software providers already in the 1980s.

Hence after starting broadly, the years 2015–2017 showed a clear focusing: Agriculture input providers moved towards agronomic advisory. Agricultural equipment providers focused on completing their portfolio with more precision application solutions.

Then, overall, after 2017 the development stalled. The financial potent players in the market were focusing on the consolidation of their "classical" business with a series of mergers and acquisitions and other players like distributors did not step in, due to the lack of financial strength and not the same degree of R&D experience.

Kearney expects that in the coming years the trend towards fully integrated farming solutions as a true differentiator in the market will gain speed again and we will see providers with a sophisticated offering, targeting the professional farming sector, in particular in Eastern Europe, North America and the large farms in Brazil, with a complete offering:

- Digital Solution Platforms - cloud-based, machinery integrated SaaS solutions for farm management along the whole crop cycle
- Advanced Satellite Image Analytics: agronomical and crop yield analytics, prognostics and monitoring services
- Farm Management Information and Operations Systems: end-to-end farm business and regulation management software
- Precision Farming Machinery and Services: software integrated precision farming equipment (trading model) and services.

This will need to be accompanied with the change of business models from product sales to offering solutions as we are seeing it in the market already.

2.1.4 Implications for the Industry: From Product to Service

The traditional farm input model is changing significantly. Still, seed, fertilizer and agricultural chemistry are brought to the grower primarily through farm retailers/distributors. The grower is receiving separate agronomic advice. The future model will likely rather have a digital recommendation and application platform for holistic in-field crop management (see ◘ Fig. 2.6), as long as legally possible. This can substantially alter the balance of the power in the market, similar to other industries. This is similar to retail, where today also buying information and recommendations are given together with the opportunity to order.

As the most substantial change for the Ag input industry, however, we foresee the transition from product to service. Until now, in almost all parts of the agriculture input industry the focus was on selling a product—seed, herbicides, a tractor, etc. However, the main intention of a grower is not to buy a specific amount of herbicides, but rather to have a weed-free field with ideally minimal long-term detrimental impact on the soil. The solution of the agriculture industry moving forward,

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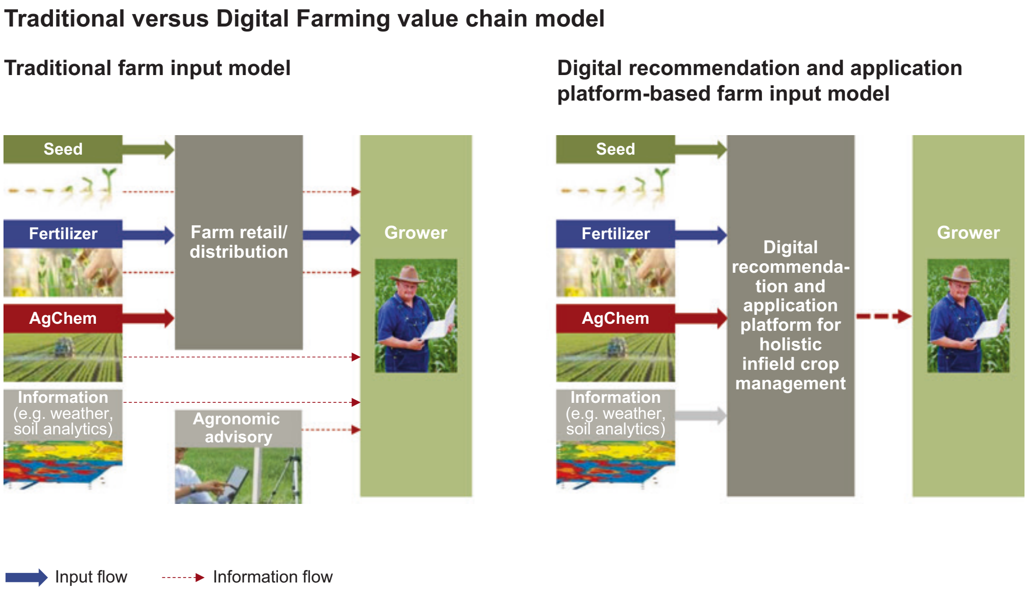

Fig. 2.6 Changing business models

hence, should be to meet exactly that demand of its customer. Provide a weed-free field with minimal environmental impact. Thus far, the thinking of the big input providers is product-oriented—revenue and profit are more or less directly proportional to the amount of product sold. And incentive schemes are linked to that. A facility manager tasked with cleaning an airport is not paid by the amount of cleaning products used, but father by the area cleaned. Big Ag will need to adopt a similar model. When quantity of product sold is no longer the key performance indicator, the industry can quickly pick up service models. That comes with big transformations, though. For example, industries so far were used to highly centralized production and then distributing via a variety of sales channels to even the remotest parts of this planet. They would make profits in excess of 20% EBITDA with a comparatively small workforce and limited equipment investments except for the central production facilities. A service model in the future will bind more capital and manpower for servicing machinery, drive down relative margins and need substantial capital investments/financing.

But future-proof business models even go beyond products and services in the long run. In terms of technology applied, crop protection and seed need to be complemented by the beforementioned data science and equipment, e.g., robots.

Products will be added services and holistic solutions up to an integrated business. There are three main additional offerings we see: automated services provision, running agricultural service contractor business, and perhaps in the long-term running owned farming business (see Fig. 2.7).

2.1.5 Digital will Change the Face of Farming

The most visible impact of digital will be regarding the type of machinery used in the field. Ever since field labor came up it was the ambition in industrialized agriculture to minimize the costly la-

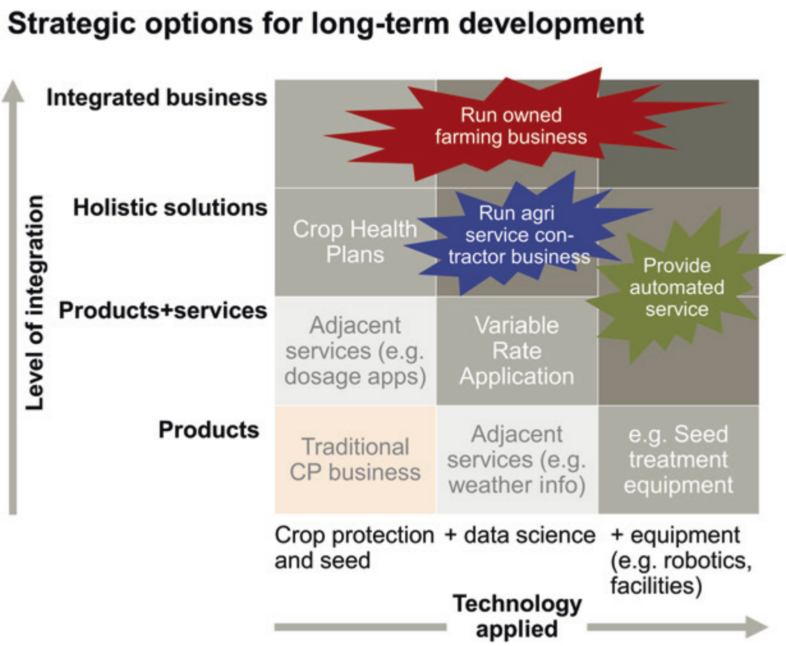

Fig. 2.7 Future-proof business models for the Ag input industry beyond products and services

bor part. This led to machinery becoming bigger and bigger, with only a single operator and combines with a width of 14 m or sprayers 50 m wide, which are not only able to cover large amounts of land fast but also could be operated by a single person. This drove the labor cost down. With the advent of autonomous robots taking over more and more jobs in the field, ultimately from planting to harvesting, size will no longer matter and we will come back to small, independently operated swarm robots in the fields (see Fig. 2.8). They will likely be powered by renewable energy (photovoltaics, e-batteries, fuel cells or synthetic fuels). The main challenge today is that they do not have the power for intense physical work like plowing, harrowing or harvesting. However, we understand that this is no principal problem but only needs some more development.

For agricultural robots to take over broader market shares, we see four criteria that need to be met.

1. Proper sensing technology, e.g., spectrometry of leave color to detect plant health status and camera technology to identify pathogens based on shape recognition. Weeds need to be identified among crops. Fungi or volatile organic compounds need to be identified, e.g., through high-speed gas chromatography.
2. Artificial intelligence/algorithms: pattern recognition to identify shapes of weeds, insects, fungus induced decomposition, etc. It is important to check against thresholds, e.g., characteristic patters for economically relevant pathogen pressure. Decision making will need to be based on pattern and threshold comparison.
3. Actuation and application: in-field movement needs to be automated, application technology needs to be developed for spraying, spreading, etc. Mechanical weeding technologies like pulling out, stamping down, cutting off, etc., need to be further developed. Advanced technologies like laser-based weeding and insect control need to be implemented.

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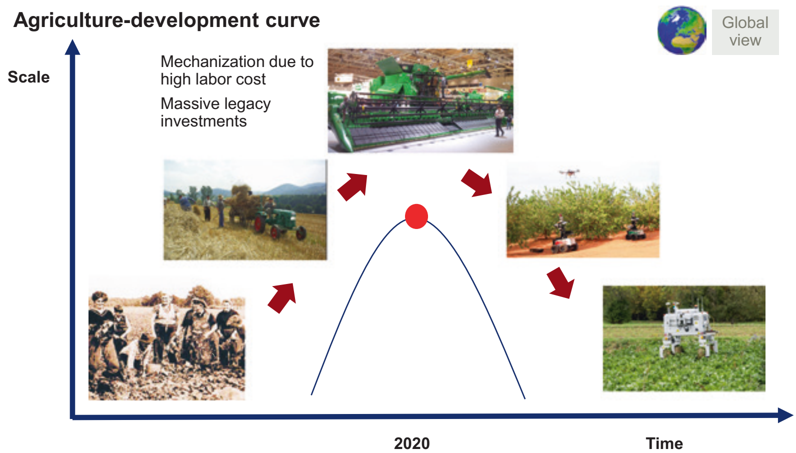


Fig. 2.8 Agriculture development curve back to smaller machinery

4. In-field infrastructure/logistics: energy supply, e.g., via on-board photovoltaic panels, supplementing charging stations at field borders to re-charge, ideally based on renewable sources. Inputs like fertilizer, AgChemicals and other consumables likewise need to be supplied.

2.1.6 Outlook: From Farm to Fork and Back

The sections before have mainly described how the existing agriculture value chain—mainly up to the farm—will likely change due to digital.

On their way from the farm gate to the retail shelf most agricultural products get substantial price mark-ups, often in the order of magnitude of a factor of 5–10 or more. This is especially the case with processed foods. The value of corn, sugar and fat in 1 kg of cornflakes is below 50 Cents; the retail price hits 5 € and more, though. For sustainable products, this retail price is likely to double or triple, far beyond what most consumers are willing or able to pay. Mark-ups at the retail level of up to 10% are acceptable to roughly two thirds of consumers, if—and only if—they can be sure that the products meet the stated specifications [GPD20]. This provides another opportunity for digital in agriculture. Tracking and tracing production methods in the field and onwards to the consumer—from farm to fork. Digital may provide a means to better communicate quality features of the agricultural products through tracking and tracing technologies, ultimately realizing a better product price at the retail level.

Finally, in an economy that is turning more and more circular, agriculture will play an important role: on the one hand as provider of bio-based feedstock and on the other hand as off-taker of post-consumer material. For the management of these circles, digital support will also be of vital importance.

The "bioeconomy" will use biotechnology for the production of bio-based goods from biomass as the main feedstock. In several geographies, governments and regulators are crafting bioeconomy strategies accordingly. The OECD started as early as 2006 and the EU followed in 2012.

The potential is huge, with over 15 bn tons of biomass being produced annually. The more of this biomass is taken from the fields, though, the greater is the need to feed post-consumer material back into the circle and onto the fields. This poses huge challenges. The agriculture industry on a massive scale ships proteins and nutrients around the globe and latest at the consumer loses track of composition of its products. To take the nutrients from post-consumer products back into the fields will require additional digital support in sophisticated reverse supply chains with tracking, tracing and testing.

With circular economy becoming the most relevant future topic, agriculture can redefine its role in the environment. The focus as of now is primarily on closing the carbon cycle and reducing the emission of CO_2 from fossil carbon sources. This has been widely understood in the wake of the Paris agreement and finds its way into the company reality with 2020 being a key year in that regard. Activist activity like Fridays for Future and regulators alike (EU Green Deal) in combination with the financial markets drive fossil carbon reduction into implementation, opening up room for the next circles to be closed.

2.2 Beyond Digitalization: Major Trends Impacting the AgFood System of the Future

Stefanie Bröring, Otto Strecker, Michael Wustmans and Débora Moretti

Abstract

Interrelated disruptions on agriculture are not only broadening the horizon of change but are also clarifying opportunities and challenges guided by continuous innovation in the marketplace. Data from one of the richest European databases for trend analysis, Trendexplorer, reveal that currently, 16 different mega-trends are affecting the AgFood system. From these mega-trends, we identify three major disruptions that may change the rules in food and agriculture, namely digital-driven disruption, sustainable-driven disruption and societal-driven disruption. By drawing on selected case studies, we also discuss how the different trends and resulting disruptions relate to each other. We thus further explore specifically the impact of the digital disruption on the AgFood system, providing an analysis of different scenarios, in which the blurring of the boundaries between the different sectors and technologies affecting current industry structures is illustrated. Based on this discussion, firms of different industry origins may better understand the opportunities that are emerging, the necessary resources and capabilities needed to conduct strategic renewal, and how this affects both their positioning and the fit of their strategy in this game.

2.2.1 Introduction

Following a worldwide trend, the AgFood system has been subject to a profound transformation driven by the application of new technologies previously used elsewhere and fostered by the increasingly demand for efficiency, food security and sustainability (see ► Sect. 1.3 and 2.1). Such transformation opens new opportunities for innovation and induces new behavior patterns [BLW20]. Accordingly, the digitalization of the AgFood system—although inevitable, one could argue—comprises only partly the renewal process. Smart sensing, but also biotechnology play a big role, for instance, in the reduction of pesticide use. This suggests that the combination of different knowledge areas and technologies is necessary to reach a major goal, composing a System of Systems (SoSs) [PH94].

Moreover, one may not forget that technological disruptions do not occur in the vacuum and may hinder or reinforce other trends. Technical change will not only provoke the evolution of the economic system but also shape new societal rules [Per02]. In order to fully exploit this potential, the actors involved should try to think systemically, towards the entire innovation ecosystem, spanning industry borders [AK10]. Ecosystems are very dynamic and often emerge from the convergence of different, hitherto separately functioning business sectors, such as IT and agriculture. The possible convergence of such industries [Bro10], triggering new ecosystems, increases the complexity of knowledge and innovation management mechanisms involved in intra- and inter-organization interactions. However, only an expanded view will allow firms to successfully identify the potential for new business models and opportunities.

We, therefore, use the following questions as a guide to our reasoning: Which are the main disruptions affecting the AgFood system and how do they influence each other? Focusing on digitalization, what are the main challenges, resulting in strategic options, and needed capabilities that firms must develop, first to survive in the marketplace and second, to exploit new opportunities?

By shading some light to those issues, we highlight three main contributions of this section. First, we expand the scope of what is usually understood of agriculture 4.0 and bring other perspectives (for example social) to the table, balancing the technocratic bias of this (r)evolution. Second, we turn our attention specifically to the digitalization of agriculture and provide an analysis of strategic management practices, which companies may use to deal with such transformation. We finalize the section by merging both macro- and micro-perspectives and end with questions that may influence decision-makers in their strategies.

2.2.2 Innovation is Multi-Systemic—Main Disruptions from Farm to Fork

To navigate in times of change and uncertainty is naturally challenging although to some extent predictable. To understand which paths society is following, we use trend data from one of the richest European databases for trend analysis, the Trendexplorer from TRENDONE. Trend data include textual information about emerging technologies, research developments, and product launches and are a common source used by practitioners in foresight activities to identify innovation fields [DU08]. The TRENDONE approach subdivides trends into three categories, namely micro-, macro- and mega-trends. **Micro-trends** consist of short descriptions with the above-mentioned content. They are allocated to **macro-trends** that describe change occurring within a medium timeframe. Macro-trends frame jointly a **mega-trend**, such as globalization, demographic development or digitization that describe long-term change. From the database, we take a broad approach looking for trends related to agriculture and extract 16 mega-trends, from which we identify three major disruptions that may fundamentally change the rules in the AgFood system: digital-driven, sustainability-driven and societal-driven (see ◘ Fig. 2.9).

Each of the 16 mega-trends exhibits 3 to 9 macro-trends, which are composed of 330 micro-trends in total. For instance, the mega-trend food culture encompasses the following four macro-trends: Newtrition, Food Fashion, Slow Food, and Performance Food. Due to topics such as alternative protein, the mega-trend food culture appears more frequently than artificial intelligence. This analysis allows us, on the one hand, to trace the multiple influences shaping innovation in agriculture and, on

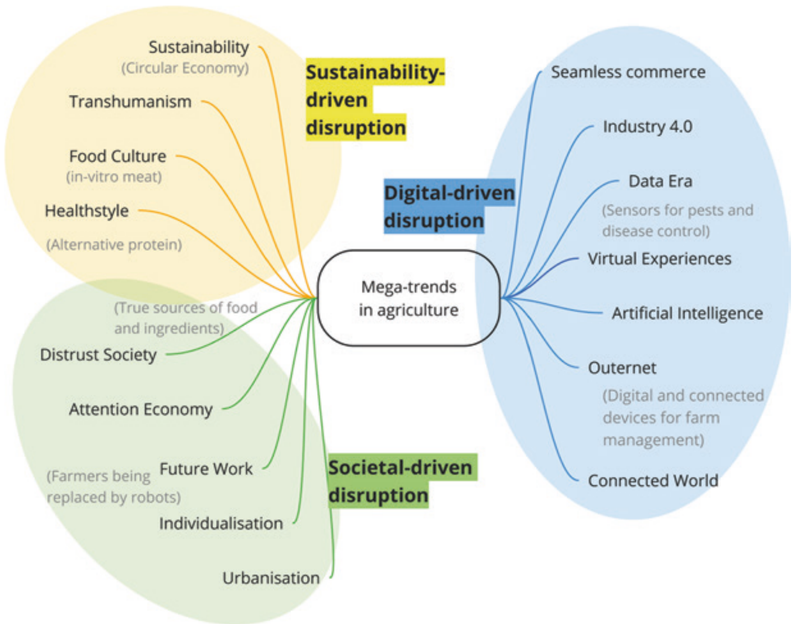


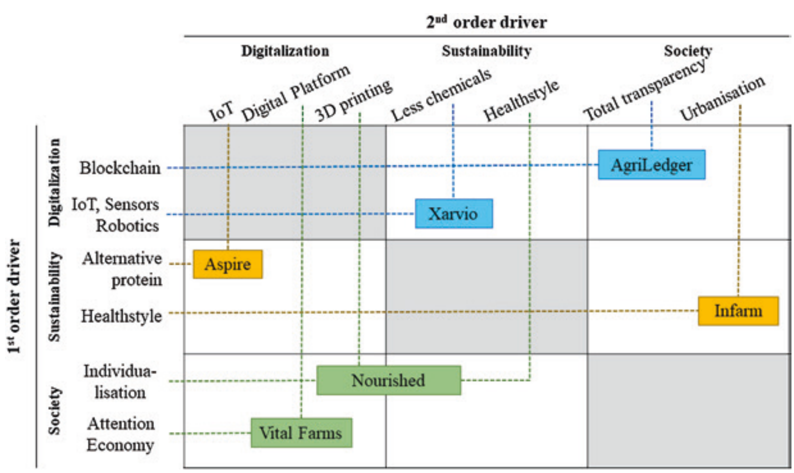
Fig. 2.9 16 Mega-trends related to agriculture. Practical examples are highlighted inside some of the mega-trends of most importance to the AgFood system

the other, to recognize the plurality of impacts that transformation in agriculture may provide.

The **digital-driven disruption** originates from the advances of artificial intelligence, Big Data, and IoT, which must be adapted to the agriculture sector both in terms of functionality and compatibility, considering the several systems that are mandatory to the user, mainly the farmer. Interestingly, the disruption encompasses expected trends—Industry 4.0 and Data Era, for instance—and emerging concepts, as Outernet, which represents the level of digital integration of previous pure physical things. The French start-up MyFood (myfood.eu) represents an example, as it developed a small greenhouse to be installed in houses and restaurants in the city. Such cases are rarely developed without sensors that can be controlled by online platforms and apps. Thus, the separation of digital and physical, offline and online, is becoming blurred. Apart but not necessarily detached from digitalization, the **sustainability-driven** disruption encompasses four mega-trends: Sustainability (which includes concepts such as Circular Economy and Zero Waste, see ► Sect. 1.3 and 2.1), Healthstyle, Food Culture, and Transhumanism. Of interest, Healthstyle points to personalization, to which the macro-trend Data Era plays an important role. In its turn, Food Culture regards to new fashions and new alternative sources of nourishment, leading to further exploration of biodiversity and the recombination of existing resources. Case in point, bioengineering, including CRISPR-Cas, represents the mega-trend Transhumanism, which relates to the ability to modify organisms with biotechnology tools. Last but not least, **societal-driven disruption** will relate to mega-trends that are both cause and effect of innovations. For instance, Urbanization is a growing trend, which calls for solutions that allow the accommodation of the majority of the population in urban spaces. To tackle this challenge, Vertical Farms and rooftop farms are becoming increasingly popular, providing fresh and healthy food, while saving transport costs and diminishing land use, although energy consumption is still a challenge. Not only, trust from society should not be taken for granted, implying transparency and effective communication among different actors of the value chain (farmer to end-consumer, for instance) as two of the major trends from societal-driven disruption.

As mentioned beforehand, these different disruptions to some degree reinforce each other. Here, the cross-influence among the three disruptions opens up room for new business models that design value propositions matching the different mega-trends (see ◘ Fig. 2.10).

For instance, the US company Aspire (aspirefg.com) draws on robotics and automated data collection to grow insect protein on digitized farms. Alternative protein sources are a sustainability-driven trend (first-order driver) and have been supported by modern technologies (second-order driver). The company connects several farms via Internet of Things, allowing high predictability for yields and reproducibility among the farms. It creates a whole new concept of farming, which might redesign the image of agriculture understood by society. On the other hand, the BASF brand xarvio (xarvio.com) focusses on digital farming solutions such as the "field manager" and, thereby, takes advantage of multiple emerging digital technology systems enabling precision farming (first-order driver) but also provides an answer to increasing demand for sustainability (second-order driver). Other examples are (1) Infarm (infarm.com), an urban farm model that provides fresh food grown in cities, enabling increasing urbanization; (2) AgriLedger (agriledger.io), which uses blockchain technology to help farmers in Haiti sell their produce at better prices; (3) Nourished (get-nourished.com), a business fostered by individualization trends, that supply personalized 3D-printed high-impact vitamins; and Vital farms (vitalfarms.com) an initiative to approximate buyers and farmers, by labeling every egg carton with the names of the farms where they came from and then providing 360° view on the respective farm.



◘ **Fig. 2.10** Start-up and company responses to mega-trends. Cross-influence among the three disruptions: digital-driven, sustainability-driven, and societal-driven. The disruptions can be both the main goal of a new value proposition of the start-up examples, acting as a first-order driver, or the enabler of another disruption, serving as a second-order driver

2.2.3 Focus: Digital Disruption and Its Implications for Involved Agribusiness Companies

Digitalization as a mega-trend has the potential to disruptively change AgFood technologies as well as existing business processes and business models. In agriculture, for example, digitalization is an essential lever to use resources more efficiently, to facilitate work processes, to be more animal-friendly, and to produce and sell sustainable, high-quality food. The players in the AgFood system, which includes traditional companies, global players, and numerous AgTech start-ups, have recently recognized the **potential** of digitalization for themselves and the entire sector [HWB19]. Still, this leads to the following three major challenges for agricultural players.

2.2.3.1 First Challenge: Dealing with an Increasingly Complex Knowledge-base

The blurring of boundaries between the AgFood system and information technology (IT) as well as the trends allocated to digital-driven disruption indicates that the knowledge-base for all players along the value chain is expanding. So, what are the key capabilities and knowledge areas for a digitalized AgFood system? While looking at the knowledge base of different digital technologies, one can observe that next to rather obvious knowledge areas such as data science, new knowledge areas emerge, i.e., bioinformatics, synthetic biology, geoinformatics or nutrigenomics to name a few (see ◘ Fig. 2.11). Some grounding technologies and innovations were highlighted as examples connected to the disruptions mentioned in the previous section, which are spanning over different steps of the value chain. A clear change in the value chain relates to its circular potential, as technologies also allow the reabsorption of outputs and waste again into the chain. Moreover, the technology systems are increasingly connected with each other. This connection and the emergence of novel technological systems is not only driven by the technology push (i.e., emergence of new functionalities and applications of enabling technologies) but also increasingly by societal pull triggering novel regulations (i.e., increasing ban of using certain pesticides). Here, the EU Green Deal will certainly foster the diffusion of smart farming technology systems such as smart spraying systems allowing to reduce the usage of pesticides, as, e.g., the smart sprayer project of Amazone, Bosch and xarvio nicely demonstrates [Ama21].

2.2.3.2 Second Challenge: Dealing with New Players from Outside the Industry due to Convergence

A look at the impact of digitalization on the AgFood system shows that also the value creation structure in the AgFood system is becoming increasingly complex, as not only new fields of science and technology become relevant (see ◘ Fig. 2.11) but also new players from outside the industry are entering the market, and industry boundaries are dissolving [Bro05], [HWB19]. More precisely, the blurring of boundaries between the AgFood system and the digital economy can be described in more detail using four different scenarios (see ◘ Fig. 2.12). These four different scenarios are not mutually exclusive but run in parallel, with individual players even participating in different scenarios at the same time.

In **Scenario 1**, the AgFood system is the driver of converging technologies and responsible for the increasing blurring of industry boundaries by developing and integrating digital skills. This scenario occurs when agricultural companies train the

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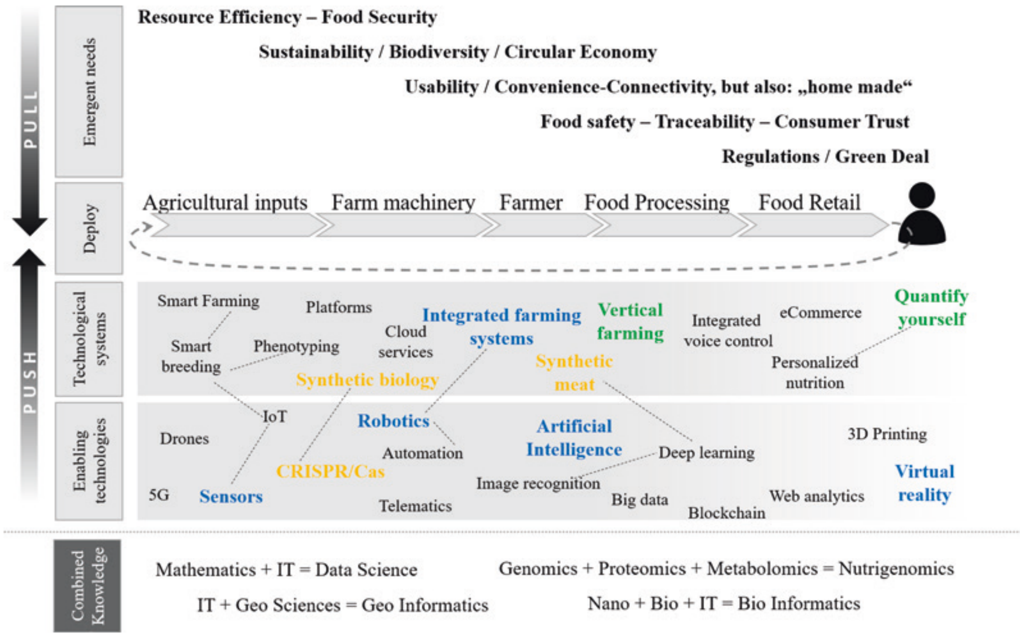

Fig. 2.11 The AgFood system between Tech PUSH (the combination of distant knowledge fields to the emergence of new Technological systems) and societal PULL

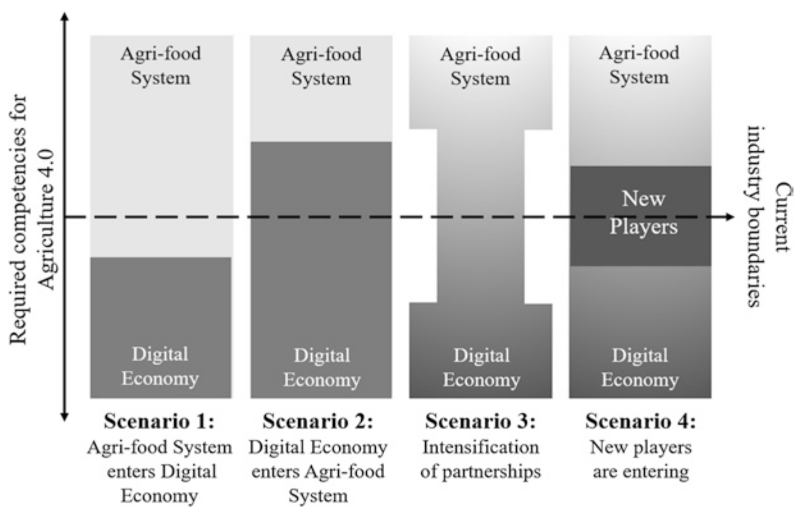

Fig. 2.12 Scenarios to depict the blurring of boundaries between the AgFood system and the digital economy. Source: Authors, based on [BPS+15] and [HWB19]

existing staff, hire new staff that is already trained, or buy and integrate IT-driven companies. For example, in 2017 John Deere acquired the start-up Blue River Technology as it focused on computer vision, robotics and machine learning applied to smart machines [Dee17]. Another example is the fertilizer supplier Yara, who purchased the Berlin-based AgTech start-up Trecker.com in 2018 to extend its recently established business unit "Digital Farming" [Yar18].

In **Scenario 2**, on the other hand, IT-driven companies, such as Amazon, Google, IBM or Microsoft, penetrate the AgFood system. Platforms such as IBM Watson and Microsoft FarmBeats aim to help the farmer to make decisions [MR18]. In **Scenario 3**, AgFood and IT companies enter into cooperation. For instance, the pig farming corporation Dekon Group and pig feed supplier Tequ Group cooperate with Alibaba Cloud, aiming the use of sensors to analyze the behavior of pigs to digitally record pig pregnancies or diseases at an early stage, and provide appropriate feedback so that respective measures can be initiated [Pen18]. **Scenario 4** shows typical investments in start-ups that create new players on the borders between the AgFood system and the digital economy. Some of those start-ups are able to join multiple worlds: The Israeli Phytech was invested by Syngenta, Tencent Holdings, and Mitsui & Co; corporations, respectively, coming from the agriculture, IT and trading sectors.

2.2.3.3 Third Challenge: Exploiting the Right Strategy and Identifying the Necessary Capabilities to Thrive in such a Complex Ecosystem

Up to this point, we explored the complexity of the current AgFood system [SEW+10] and provided an overview of players and knowledge fields that are contributing to it. This brings us to the third challenge: the plethora of actors and systems must be well aligned towards unique value propositions. For companies, this means that it is not anymore about producing and selling products or offering specific services, but engaging with the whole ecosystem. Therefore, we ask: which strategic options do companies have and what does that imply in terms of capabilities? We start our answer following [HE18], who describe three strategies in ecosystems: the system, the component and the bottleneck strategies (◘ Table 2.1).

The **system strategy** is characterized by a higher level of control, where one company chooses to simultaneously enter multiple components, reducing its dependency on complementors. If different components are to be produced and commercialized by one company, integrative capabilities are essential, i.e., the organization must be highly capable of combining products, resources and knowledge to secure in-house development [HR18]. The John Deere Com-

◘ **Table 2.1** Strategies and capabilities to navigate the ecosystems. Source: Authors, based on [HE18], [NS11] and [HR18]

Strategies	Capabilities
Bottleneck—enter the bottleneck component at the founding, and new ones as they emerge	**Innovation capabilities—**opportunities through product sequencing
Component—enter one or a few components and cooperate for the rest	**Scanning and sensing capabilities—**towards core products as well as complementary asset providers
System—enter multiple components and minimize cooperation	**Integrative capabilities—**introduction and modification of products, resources, and business models

pany seems to apply this reasoning. Taking advantage of its large resource base, they developed several digital platforms in-house, namely MyJohnDeere, Field Connect™, AgLogic™ & DigiConnect, targeting the different ecosystem actors. The **component strategy** relates to parts of systems that may take innovation to the next step. Such a strategy is less resource-intensive in terms of development, but rather requires scanning and sensing capabilities not only to keep innovating the developed component but also to identify complementors that will increase value creation. The case of the Israeli start-up Prospera illustrates this strategy, as they received investment from Cisco and Qualcomm, two hardware leaders. Both corporations enter the agribusiness with a component, and secure value creation through complementors [Pee17]. Finally, the **bottleneck strategy** is as complex as potentially successful. It can be regarded as a specialized type of component strategy where the component is a bottleneck for the whole ecosystem to grow, due to poor quality, poor performance or short supply [HE18]. Microsoft FarmBeats came into place not only as a management platform for farms but also to solve a bottleneck issue: farm connectivity. It is expected that Microsoft continuously innovates in this bottleneck, bringing connectivity to the most remote areas, whereas the company must maintain its eyes open to possible shifts in this bottleneck. Another example comes from Agrirouter (DKE-Data) that allows data integration in a single system independent from the technology suppliers.

2.2.4 Concluding Questions

We started this section by calling attention to the substantial change that the AgFood system is currently facing. This change is not restricted to the use of new technologies, but may indeed transform society, as well as technology development is influenced by societal trends. To shed some light on the different disruptive forces, we draw upon a trend databank to depict the three major disruptions potentially transforming the AgFood system, namely digital-driven, sustainability-driven and societal-driven disruptions. It seems pivotal to be alert to these dynamic developments since all disruptions are connected and not only influence but also potentially reinforce each other. It is, however, not clear which vision do the incumbent corporations have regarding the future and especially if such vision differs among companies previously coming from the AgFood system or the digital economy. Moreover, it is unclear how incumbents should best partner with start-ups who are perhaps more agile to design and test their value propositions.

However, the definition of such a vision is not only important to the firms themselves, as it affects their strategy and triggers their renewal. It seems also of utmost importance to governments and other stakeholders that are willing to influence sustainable development. For instance, digitalization is only a concern regarding unemployment, if the work force is not reallocated (and accordingly educated) to the new knowledge and application fields that are emerging. Therefore, what is the role of universities and their faculty structures—perhaps these need to cooperate even more to account for the needed knowledge combination as innovation in the AgFood system happens at the interface of different knowledge fields?

We further highlight three main challenges for companies that are embedded in this context or that are focusing it. The digitalization of agriculture brings new players to the game, different knowledge fields, and therefore different strategies. As a consequence, new threats or new opportunities for collaborations are at place. In order to allow for a timely response if not a proactive action, one should scan its own resources to understand how prepared the company is to absorb new knowledge from related ecosystem partners, or implement innovations out of its core competencies. Are the companies entrepreneurial enough to risk out of their comfort zone? Are they aggressive enough to aim for system strategies? How does the business model need to be adapted? Will they follow or orchestrate emerging (digital) platforms and eco-systems? What industry will be more successful and act as orchestrators in the AgFood system of the future: Big IT- or AgTech? What will be the role of the farmer in the future—just owning land, or even less if the farm-free food movement diffuses?

Moreover, one could ask: do all those changes impact and change value chains? If robots and autonomous vehicles substitute farmers, artificial intelligence platforms substitute advisors, and marketplaces connect farmers and consumers directly, changes are to be seen. Up to this point, it is rather clear that value chains are not enough to encompass all the relevant actors and the larger ecosystem perspective should guide as further.

2.3 Economic Benefit Quantification

Peter Breunig

Abstract

This section provides an overview of how economic value is created through digital solutions, which cost is involved in using these technologies, and how the economic benefit is calculated. In addition, the limitations of the economic benefit model are described followed by an example.

2.3.1 Introduction

Although economics are not the only driver for the adoption of technologies (see ► Chap. 1), understanding the economic benefits of digital solutions from a farm-level perspective is relevant for farms themselves as well as the companies offering these technologies. Farmers need to understand the economics behind digital solutions to do the right investment decisions for their operation. Agribusiness companies on the other hand need to understand the farm-level economics of their offering for value-based pricing and to convey the value to customers during market introduction. Even early in product development, when final costs of a solution are not yet foreseeable, quantifying the economic value of potential solutions might help to prioritize development projects.

The following content focusses on arable farming only, although the underlying logic can be transferred to other types of farming as well.

2.3.2 Fundamentals of Economic Value Creation

To understand the economic benefits of digital solutions, we must first understand how digital solutions create value for arable farming in a way that can be quantified. There are five main ways of how value is created:

1. **Improve job execution**
   Digital solutions help to execute a job like planting, spraying or fertilizer application better. These improvements are based on two dimensions: higher precision and increased output.
   1. **a) Higher precision**

Higher precision is achieved in three ways:

- Less variability of defined job quality parameters: Technologies like advanced planter monitors allow to adjust tractor speed to ensure a defined singulation quality and placement of seed. NIRS-based nutrient sensing in organic fertilizer application ensures a more precise application of actual nutrients. In harvesting grain, cameras enable automated settings adjustments which ensure a consistent grain sample in varying crop conditions.
- Reduced overlaps through technologies like autosteer and section/nozzle/row control: GNSS autosteer, especially using RTK-correction signals, reduces overlaps between machine swaths in the field. GNSS-controlled shut-off of sections, single nozzles, and planter rows minimizes overlaps on headlands and irregularly shaped fields.
- Adopting input application and machine settings to sub-field variability based on soil, slope, weed distribution, and other factors affecting crop growth: Technologies like Variable Rate Application and spot spraying allow applying inputs on a sub-field level optimized to a specific zone or even a single plant. Variable tillage and seeding depth allow machine settings to vary on a sub-field level based on the requirements.

1. **b) Increase output**
Digital solutions can improve job execution by increasing output per operator hour, i.e., hectares worked per operator hour.
   - Reduced overlaps between machine swaths in the field enabled through GNSS autosteer increase the output per operator hour: This is especially relevant for large equipment with wide working widths.
   - Higher speed: Digital solutions that analyze machine performance or automatically adjust machine settings based on conditions allow machines to always run at the maximum speed possible. Examples for these technologies are monitors or speed-automation systems for planters (TIM) and combine harvesters. These systems outperform in most cases speed adjustments by the operator, especially in longer shifts, and lead to higher average working speeds.
   - Autonomous operation: Output per operator hour can be drastically increased when machines operate autonomously. This means that one operator can manage several machines at the same time.
   - Less downtime: Digital technologies enable remote diagnostics of machines, remote support, and other solutions to reduce machine downtime and increase output.

2. **Improve management processes**
Digital solutions can help to speed up management processes and reduce errors.

2. **a) Simplify job planning, controlling and documentation**
Digital farm management information systems (FMIS) increase speed and reduce errors in job planning and execution. In combination with telemetry systems, job plans can be sent remotely to machines and the execution can be controlled from the office. Documentation can also be simplified and even automated using digital FMIS.

2. **b) Improve purchasing and selling**
Digital marketplaces allow farmers to get quotes from input suppliers faster and simplify selling of commodities including logistics. Furthermore, these trading systems often provide access to more potential sellers and buyers of inputs and commodities compared to current practices. In addition, disintermediation (i.e., the reduction of intermediaries

like commodity traders or input dealers within the value chain) as well as the aggregation of demand (e.g., several farms aggregate their demand and purchase inputs together) enable better selling and purchasing conditions.

3. **Improve decision making**
Besides improving the execution of jobs and processes ("doing things right"), digital solutions also create value by enabling better decisions ("doing the right things").

3. **a) Agronomy**
Agronomy decisions include questions on which operations should be done when and how as well as which inputs should be applied at what rate and point in time. When applying inputs on a subfield level, i.e., based on defined zones or even single plants, the number of required decisions increases significantly. Digital systems using crop/disease models, expert systems, or machine learning can lead to better decisions (e.g., higher yield and less inputs) and/or faster decisions. Currently, available solutions are moving from tools that support decisions to prescriptions that almost fully automate decision making.

3. **b) Equipment related**
Farms need to take equipment-related decisions about machine logistics (which machines should do what, when and where?), machine settings, and repairs/maintenance (when to change which parts?). Telemetry systems using machine sensors in combination with smart analytical tools allow farms to improve decision making and can enable better logistics, improved machine settings, and optimized repair timing (predictive maintenance).

3. **c) Business related**
There are numerous business decisions farmers need to take throughout the year like input purchase or crop selling. On a longer-term perspective, farmers need to also take business decisions on renting or purchasing land and how to use their fields. Digital platforms can support regular business decisions by providing price and market information. Also, strategic decisions around land expansion and land use can benefit through tools like profit zone field-maps and digital platforms that provide land value and land productivity information.

4. **Enable new production systems**
Besides improving single jobs, digital technologies can also enable new production systems, i.e., the sequence of jobs like tillage, planting, crop care, etc. to establish a crop. For example, controlled traffic farming is enabled through RTK autosteer and leads to fewer tillage passes. Strip Tillage is another production system enabled by RTK autosteer technology which reduces tillage to a small zone around the crop rows. Potentially, smaller autonomous machines could make new diverse copping patterns with various crops within one field possible.

5. **Provide data for partners along the value chain**
Digital farm data can provide value to up- and downstream partners along the value chain. Examples are machine or agronomic data that helps machine manufacturers or input companies to optimize their offering. Although there are only very few cases so far in which farms are paid directly for their data (e.g., Farmobile LLC), this would be possible and would create additional revenue for farms.
Farm data can also provide value downstream the value chain. In this case, certain production methods or environmental benefits can be traced through digital data leading to possibilities for farms to differentiate their commodities and directly react to customer needs and wants. Although these systems are still in development, there seems to be a significant potential for higher prices and

additional revenue (e.g., carbon market) for farms.

To quantify the economic value of digital solutions, we need to connect the ways value is created with revenue and cost on the farm level.

Revenue is yield multiplied by price plus additional revenue streams. The relevant cost groups are direct cost (cost for seed, fertilizer, plant protection plus variable irrigation cost, crop insurance and drying energy cost) as well as operating cost (variable machinery cost like repairs, fuel cost, depreciation, finance for machinery, labor cost, and contractor cost). Overhead cost (building depreciation and interest, land, property taxes, building insurance, and miscellaneous items) are usually not influenced by digital solutions.

The overall economic value created by a digital solution on the farm level is equal to the changes in revenue, direct cost and operating cost of the farm's production system in comparison with the situation without this solution.

Economic Value to the Farm = RvC + DCC + OCC = (Y*PC + YC*P + YC*PC + AR) + DCC + OCC

RvC = Revenue Change, Y = Yield, YC = Yield Change, P = Crop Price, PC = Crop Price Change, AR = Additional Revenue, DCC = Direct Cost Change, OCC = Operating Cost Change

It is important to note that one solution could offer an advantage on one revenue or cost item but have a disadvantage on another one. E.g., spot spraying decreases herbicide costs (DCC) but increases operating costs due to lower speed (OCC).

▣ Table 2.2 shows how the ways digital solutions create value relate to relevant revenue and cost items on the farm level.

2.3.3 Cost Structure Fundamentals of Digital Solutions and Economic Benefit

Besides the economic value that digital solutions provide, there is also cost involved in using these technologies. These costs can be divided in variable cost (depended on the utilization) and fixed cost (independent of the utilization).

Variable cost of digital solutions consists of the following three cost items:

1. Repair and maintenance cost: Hardware components of digitals solutions may require repairs or maintenance. One example would be the protection glass of NIRS sensors used in self-propelled forage harvesters which needs to be replaced regularly based on usage.
2. Variable labor costs: E.g., if application maps are created on the farm, there is a certain amount of labor required to do these operations including operational inefficiencies, partly due to interoperability issues. This amount is dependent of the number of fields for which application maps are created.
3. Variable licensing and data cost: Sometimes licensing fees, software subscriptions, data and data transmission cost, and data transformation or adaption cost are based on the usage and therefore variable costs.

Fixed cost are made up of these four cost items:

1. Depreciation: To allocate the usage cost of a tangible asset over its useful life, depreciation is used as part of fixed costs. Usually depreciation is calculated as follows: (Purchase price—salvage value) / usage.
2. Fixed labor cost: Labor cost involved to start-up a technology (once or several

Table 2.2 Relationship between value created by digital solutions and relevant revenue and cost items on the farm level

	1. Improve job execution							2. Improve management processes	3. Improve decision making			4. Enable new production systems	5. Provide data for partners along the value chain
	a) Higher precision			b) Increase output					a) Agronomic	b) Equipment related	c) Business related		
	Less variability of defined job quality parameters	Reduced overlaps	Adopting input application and machine settings to sub-field variability	Reduced overlaps	Higher speed	Autonomous operation	Less downtime						
Examples	Harvester automation, organic nutrient sensing, planter automation	Autosteer, section control	Variable-rate application, spot spraying	Autosteer	Harvester automation, planter automation	Autonomous weeding robots	Remote diagnostics, remote support	Farm management information systems, digital trading platforms	Disease models, crop models, Seeding rate prescriptions	Predictive maintenance	Profit zone field-maps	Controlled traffic farming, strip tillage	Certification and tracing systems
Yield increase	X	X	X						X	X	X	X	
Price increase	X							X			X		X
Additional revenue													X
Direct cost decrease	X	X	X					X	X			X	
Operating cost decrease				X	X	X	X	X		X		X	

times during usage) independent of the total usage amount. For example, this could be the installation of a crop sensor on a machine.
3. Learning cost: To be able to realize the value of technologies, users must learn how to utilize them. These learning costs might include labor costs, costs for seminars, travel costs, etc. Learning costs are part of the fixed cost because they are independent of the utilization of the technology. As with depreciation, learning costs must be allocated over the useful life of a technology.
4. Fixed licensing and data cost: In addition to depreciation for hardware fixed licensing, data and data transmission cost might occur.
5. Interest: Instead of using financial assets to purchase technology solutions or for learning they could also create value through interest on, e.g., a bank account. This opportunity cost has to be considered in the cost calculation and is calculated as follows: (purchase price + fixed licensing cost + learning cost—salvage value) / 2 * interest rate.

The **total cost** of utilizing digital solutions can be summed up as follows:

Total Cost of Technology Usage = VC + FC = (RC + VLC + VLiC) + (D + FLC + LC + FLiC + I)

VC = variable cost, FC = fixed cost, RC = repair and maintenance cost, VLC = variable labor cost, VLiC = variable licensing cost, D = depreciation, FLC = fixed labor cost, LC = learning cost, FLiC = fixed licensing cost, I = interest

To understand if and how profitable the investment in a certain digital solution on the farm level is, we can now calculate the economic benefit:

Economic benefit = economic value to the farm—total cost of technology usage

2.3.4 Limitations of Economic Benefit Quantification for Decision Making

There are several aspects that are important to consider when using economic benefit quantification to understand decision making on the farm level.

1. In arable farming, the economic benefit of a technology can vary substantially between years and between farms. Due to changing weather and market conditions, the economic value of a digital solution can change drastically from one year to another. Also, farms can be hugely different in regard to soil types, crops grown, production systems, existing machinery fleet, labor availability, skill level, etc. Whenever economic benefit quantification is used to understand decision making on a multi-year and market-level instead of a single-year and single farm-level, these variations need to be considered.
2. Several aspects that drive decision making are hard to quantify in economic terms. Some examples are: Increased comfort because of automation features due to a lower stress and activity level of the operator; peace of mind caused by sensing and monitoring systems, e.g., on a planter; increasing social status of farmers due to the technology leadership image that is supported by digital solutions, which could also help to attract workers; complexity costs that occur if technologies create operational complexity for farms.
3. Some aspects of the economic benefit are not fully visible for most farms. Especially when it comes to yield effects of digital solutions, most farms are not able or willing to do precise trials to measure these effects. So, although there is an economic value that could be quantified, it is not visible for the farmer.

To give an example for these limitations, let us consider a farm that has to decide between two digital solutions that offer in this case the same economic benefit for the farm: sprayer section control and variable rate application (VRA) for nitrogen. Most likely the farm will decide to invest in sprayer section control. Why? In comparison with VRA, section control delivers value independent of yields and crop prices, it improves comfort and does not increase complexity. In addition, the economic value of VRA is not directly visible and can only be quantified with yield trials on the farm.

2.3.5 Example for Economic Benefit Quantification

In the following, the economic benefit of spot spraying herbicide in sugar beets and corn will be quantified. This digital solution detects crops and weeds and applies herbicide only on the weeds.

The assumptions are as follows:

- Farm size: 600 ha
- Crops: 300 ha wheat, 150 ha sugar beet, 150 ha corn
- Spot spraying only works for herbicide application and only in sugar beets and corn. It will require a slower speed than during broad application
- The spot spraying system is an option built on top a trailed sprayer. The purchasing price for the option is 150.000 €, its usage life is 10 years and there is no salvage value
- Herbicide savings through spot spraying (DCC):

Sugar beet:	-20% ->60 €/ha	=9000 €/year
Corn:	-30% ->30 €/ha	=4500 €/year

- Revenue increase due to less herbicide damage (RvC):

Sugar beet:	+3% yield	=12.000 €/year

- Higher operating cost due to slower speed in spot spraying (OCC):

Sugar beets:		=-800 €/year
Corn:		=-200 €/year

- Repair and maintenance cost (RC), variable labor cost (VLC), variable licensing cost (VLiC) and fixed licensing cost (FLiC) are all zero for the spot spraying system

Depreciation (D) for the spot spraying system (150.000 € purchase price and 10 years usage)		=15.000 €/year
Learning cost (LC)		=100 €/year
Interest (I) for the spot spraying system		=1.500 €/year

Based on these assumptions above the results for the economic value, the total costs and the economic benefit are as follows:

Economic value = RvC + (DCC + OCC)	
= 12.000 €/year + (13.500 €/year—1000 €/year)	= 24.500 €/year
Total cost = D + LC + I	
= 15.000 €/year + 100 €/year + 1500 €/year	= 16.600 €/year
Economic benefit = economic value—total cost	
= 24.500 €/year—16.600 €/year	**= 7900 €/year** (26 €/ha)

It is important to mention that this example only provides a positive economic benefit because of the yield increase in sugar beet. As mentioned above, this yield increase is usually not visible for farmers which might decrease the adoption of this technology. One solution to this challenge could be an outcome-based pricing model, where suppliers of a technology help to measure yield effects (e.g., through remote sensing) and provide refunds to customers, when initial yield increase targets are not achieved.

2.3.6 Summary and Outlook

Quantifying the economic benefit of digital solutions is essential for farms as well as digital agriculture companies. These solutions provide value to customers through improving job execution, management processes, and decision making as well as through enabling new production systems and providing value to partners along the value chain. There are also variable and fixed cost involved in using digital solutions, which need to be considered to understand the overall economic benefit. But there are also limitations to economic benefit quantification: variability between farms and years, hard to quantify factors like peace of mind and limitations of farms to quantify benefits themselves limit this approach.

2.4 Successfully Disseminating Digital Tools for Farmers: A French Perspective

Leo Pichon

Abstract
In France, agriculture is currently undergoing many changes and society's expectations of it are evolving. The so-called Agro-Ecological transition is tending to rethink agricultural models by relying on less chemistry but using more knowledge. Digital technology offers tools for acquiring and sharing this knowledge to support agriculture in its transition. Many digital tools have now reached a high level of technological maturity and their lower costs make them accessible to a large majority of farmers. Despite this, adoption levels remain relatively low and the use of these tools is struggling to become more widespread (see ► Sect. 1.5).
The objective of this section is to understand the factors that would allow a better diffusion of these digital tools to farmers in the French context. To tackle this issue, a collective approach has been set up between companies in the field of agriculture and digital technology and teaching and research institutes grouped within a consortium called the AgroTIC chair.
Multidisciplinary working groups analyzed real cases of successes and failures in the diffusion of digital tools to farmers. The conclusions were then shared and discussed with some 30 stakeholders of the sector. This work showed that the distributor plays a central role in the dissemination of these tools. In order for them to play their role, it is essential that these actors clearly identify the value they can find in the distribution of digital tools. This value is not necessarily financial or direct. It may, for example, be found in the improvement of his image or the quality of his relationship with his customers. This study also showed that to ensure the proper diffusion of digital tools, it is important that the distributor is involved at a very early stage in the design process.

2.4.1 Introduction

French agriculture is currently undergoing many changes driven by changes in its environment (adaptation to climate change), its relationship to society and biodiversity (agro-ecological transition) or even the organization of its sectors (separation of sales and consulting). Digital technology, because it enables observations, information or advice to be collected, stored, enhanced or shared more easily and more quickly, from the within field level to the regional scale, offers tools to support agriculture in its transitions.

In the past twenty years, some studies have started to investigate the adoption of these tools by farmers [DM03], [PCP13]. Most of them provide objective evidence on the number of farmers equipped and their level of use [MGB+17]. These studies often focus on the technical or socioeconomic factors that influence the dissemination of these tools to farmers [PT17]. However, they often focus on the obstacles that exist at the farmer level without taking into account all the actors in the value chain and their role in the dissemination of digital tools to farmers. In particular, these studies rarely focus on the value that each actor involved in the dissemination of digital tools to farmers could perceive.

The objective of this section is to (i) make an inventory of the actors of the value chain influencing the diffusion of digital tools to farmers, (ii) to identify the value they perceive or could perceive and (iii) to propose good practices to be implemented by the actors to promote this diffusion.

2.4.2 Material and Method

2.4.2.1 The AgroTIC Chair

The AgroTIC chair is a structure grouping together 3 teaching and research institutes in digital agriculture and 28 companies among the main editors and distributors of digital tools for farmers in France. Its objective is to lead collective reflections on digital technologies in agriculture, their dissemination and adoption by farmers. Its composition and the work carried out there are conducive to exchanges between all the actors involved in the dissemination of digital tools. The people who participate in the AgroTIC chair's activities are all experts in the field and generally occupy strategic positions within their companies. It is these people who have contributed as experts to this study.

2.4.2.2 The Focus Groups

The study was based on the expert analysis of use cases [Mit83] of digital tools for farmers. The use cases were selected from tools in which the experts were involved in the conception or the commercialization and thus had access to detailed data on the dissemination of these tools.

The study was carried out in the form of a focus group [KC00] in order to promote exchanges and discussions among the experts. The workshops were repeated several times with the same group of experts according to the "repeated focus group" methodology [MFG08] in order to allow the experts to formulate complex reasoning and to offer them the opportunity to mature their thinking between 2 workshops.

Three initial focus groups were conducted in January, June and October 2019 with six experts representing editors and distributors. These workshops enabled an initial analysis of the obstacles and best practices to emerge, which were then submitted to all the experts of the AgroTIC chair (around 50 people) in order to develop a collective and shared vision. This vision was then disseminated to the general public in the form of a professional conference and in a document intended for stakeholders in the sector (Fig. 2.13).

2.4.2.3 Results' Analysis

During the focus groups, experts first identified the actors who played a role in the dissemination of digital tools to farmers. They then identified on the basis of use cases the value that each actor could derive from this dissemination. This value perceived by the actors was classified into four main categories. The direct financial value corresponds to the direct sale of a tool that brings money to the actor who sells it. The indirect financial value corresponds to the sale of other tools or services that is allowed by the diffusion of the digital tool by the actor concerned. This is for example the case of a decision support tool that allows the sale of a global service including the digital tool, advice and a product. The human value corresponds to the fact that an actor will be able to improve its relationship with its customers or suppliers

Fig. 2.13 People participating to the focus group

Table 2.3 Experts identify the value perceived by each actor at different levels in the digital tool's distribution chain

Value	Actors			
	Editors	Distributors	Farmers	Influencers
Financial direct	■	■	■	
Financial indirect	■	■		
Human		■	■	■
Environmental			■	

by distributing a digital tool. This is, for example, the case of an actor who will be able to better know his customers and their expectations and thus provide them with personalized advice. Finally, the environmental value corresponds to a better protected environment or a better control of pollution thanks to the dissemination of digital tools. This is, for example, the case of a farmer who will be able to better control his inputs thanks to decision support tools.

2.4.3 Results

2.4.3.1 Actors of the Value Chain and the Value They Perceive

The results of the focus groups identified four main types of actors in the dissemination of digital tools to farmers (Table 2.3):

- **Editors** who design the tools: In France, the companies identified by the experts are often mid-sized companies that have been established for several years or start-ups and also some more traditional input suppliers. According to the experts, the editors mainly find direct financial value in the selling of their tools. According to them, this turnover can also be indirect by allowing for example the development of customer loyalty or improving the way their client sees their company.

- **Distributors** who sell the tool to the user and provide support: In France, the distributors identified by the experts are mainly cooperatives, traders or accounting centers. According to these experts, the value perceived by the distributors can be financial by being either direct through the simple resale of the tools or indirect by increasing the value of a product (e.g., decision tools optimizing the use of phytosanitary products), by allowing the distributor to better value its technical expertise, or by allowing the distributor to gain in productivity in its advice. Finally, the value perceived by the distributors can be human, modifying the relationship with their customer. The fact that the farmer uses a digital tool allows the distributors to better understand their needs, to accompany the evolution of their practices, or to increase the quality of their advice. These changes then tend to differentiate the distributors from their competitors, to build customer loyalty, and to enable them to obtain new customers.
- **Farmers** are the users of these digital tools: According to the experts, the value they perceived can be i) economic, by bringing a margin gain per hectare that is easily understood by the farmer, ii) human, by allowing the farmers to optimize their interactions with their advice and mutual aid circles or to improve their working comfort, or iii) environmental, by reducing the impact of his practices and promoting their sustainability.
- **Influencers** are people or structures that modify the behavior of other actors through the knowledge they disseminate (agricultural education, higher education, research), the advice they provide (technical institutes, independent advisers), the opinions they express (farmers' unions, politicians, media) or the funding they offer (public financiers, AgFood industries): According to the experts, these actors derive value only from the recognition they receive from other actors who trust them.

2.4.3.2 Recommendations for a Better Diffusion of Digital Tools

The recommendations below are not injunctions but a contribution of the group of experts, based on their experience, to a reflection that seems to be necessarily collective. These good practices are addressed to the actors of the value chain.

Editors: let's put ourselves in the place of others!

- Let's think about our end users, the farmers: Each farmer has his or her own way of working and the tools we design must be able to fit their specificities. Reconciling technological or agronomic added value on the one hand, and ergonomics and ease of use on the other, is a real challenge. Let's not neglect either of these two aspects.
- Distributors represent us: They are the ones who, in the field, convince farmers that our tool has value. Let's make it easy for them. Let's describe and document the benefits that our tools bring to the farmer. Our literature often devotes too much space to describing the features of the tools and too little to describing the benefits and the concrete evidence they provide.
- Distributors are also our customers: They must perceive a value in having their farmers use our tools. Let's identify this use value and integrate it into the design of our tools from the very beginning.

- Our tools must be able to fit into an existing technological ecosystem: Farmers want their new tool to integrate easily with those they already have, without re-entering existing information or becoming familiar with a new interface. Each tool is at the center of the system, but interoperability is a major objective that can only be achieved collectively. Let's promote the interoperability of our tools!

2.4.3.3 Distributors: let's be ambitious!

- Let's quantify the complementary value to define an ambitious strategy: Why are we distributing digital tools to farmers? It makes sense because of the complementary value that these tools bring to us the editors and our farmers. Let's quantify this value, let's make it tangible. We can then integrate it into our objectives, build an ambitious strategy and convince our teams to implement it.
- Let's train our teams. Our teams need support to familiarize themselves with tools that are sometimes new to them. Above all, they need to be supported in the change of profession and mentality that the transition from selling products to selling services implies.
- Let's co-construct the offer with the editors. We are the ones who will present the tools to farmers. Let's invest in their design. Let's test the tools and feedback our opinion and that of the farmers to the editors!

2.4.3.4 Influencers: let's get involved!

- Let's get out of the futuristic vision of digital tools for agriculture: Today, tools already exist and they are valuable to farmers. A number of these tools are mature and accessible to all. Some are available for a few hundred euros and are accessible even for small structures.
- Let's communicate their benefits for farmers: We are independent and we are recognized in our field of expertise. Farmers need our point of view to be reassured and get started. Let's share with them the evidence we have identified for the benefits they will find in the use of these tools. Let's encourage them!

2.4.3.5 Farmers: get started!

- Test existing tools: Make up your own mind by trying out the solutions on the market. Today, there are many solutions to test the tools yourself (test platforms, equipment loans, etc.).
- Share your experiences: Have you used and adopted a digital tool, even a simple one, and found value in it? Talk about it to your neighbors or fellow farmers. Don't hesitate to share your more mixed experiences as well. Share your customer feedback with other farmers and your suppliers.
- Trust your advisors: The people who surround you and advise you can help you in the use of digital tools. They can help you to see more clearly in the offer of services and to make the right choice according to your expectations and your context. Ask them!
- Depending on the tools, the costs can be relatively affordable and the risk limited: In any case, in a decision-support tool, it is always you who decides what actions to take in the field. Try them out!

2.4.4 Discussion

This study collectively produced recommendations to support the dissemination of digital tools to farmers. It is possible that some recommendations may be specific to the French agricultural context. For example, distributors play a particularly important role in France. It is likely that this role will be different in other European countries depending on the way the agricultural sectors are structured. Nevertheless, the method that was used to get the actors of the value chain to discuss with each other can be applied in every context. One of the major obstacles to the dissemination of these digital tools is the lack of mutual understanding of the issues and working methods for each actor. Setting up places and times for sharing point of views between these actors is a way to bridge this gap. It is important that these discussions occur in neutral places and that they are led by trusted institutions. Actors involved in this type of discussions must not expect immediate economic benefits. They must adopt a posture of building a common culture that will promote a better understanding of the reciprocal issues at stake. The digital tools will therefore be better adapted to the farmers' needs, be better distributed, and, therefore, be more easily disseminated. These collective approaches make even more sense in unstable climatic and agricultural contexts. All the actors in the value chain will have to adapt strongly and quickly. They will do so all the better if they share their point of view and know the issues and concerns of the other actors.

2.4.5 Conclusion

French agriculture is currently undergoing many changes, and society's expectations are evolving. The agro-ecological transition is tending to rethink agricultural models by relying on less chemistry but using more knowledge. In agriculture, as in many fields, knowledge has always been based on observation. Observations that are then discussed, shared, put into perspective to build general or, on the contrary, very local and specific knowledge.

Numerical tools allow for more and more objective collection of observations. They allow these observations to be stored and shared more easily and quickly. These tools also make it possible to build new knowledge on the basis of these observations. Digital tools can therefore help agriculture and its actors in the transitions they are experiencing today.

In recent years, these tools have reached a certain level of technological maturity that allows them to be accessible to farmers at reasonable costs. The multiplication of uses also makes it possible to have a perspective on the direct or indirect value that they can bring to farmers and other actors in agricultural sectors.

For these tools to have a real impact in supporting the changes that French agriculture is undergoing, a significant number of farmers must use them. This significant number will only be reached if all members of the chain are committed. First of all, farmers who have an interest in adopting these tools to improve the economic and environmental sustainability of their farms. Second, editors, of course, by continuing to invest in research and development for ever greater value, and distributors, who will create a new source of direct and indirect value for their organizations. Finally, the influencers who can make a decisive contribution to the transformation of French agriculture.

2.5 Business Model Innovation and Business Model Canvas

Gordon Müller-Seitz

Abstract

The prevalent need for innovations in today's world is commonly accepted and virtually pervades all segments and organizations (see ► Chap. 1). Hence, it is not surprising that farming is also impacted and the observation holds particularly true as business environments are changing ever faster fueled by the digital transformation. In this connection, product and service innovations pervade the discourse and managerial thinking about in-

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novations. However, compared to product or service innovations, business model innovations remain rather unexplored, but offer valid chances to develop new agricultural ecosystems (see ► Sect. 2.1). Against this background, the present section presents business model innovations as a distinct innovation form that is of utmost importance in light of digitalization. Building upon the conceptual introduction, the so-called business model canvas as a managerial tool is introduced, applied to the Digital Farming setting, and critically reflected upon.

2.5.1 Statement of the Problem

To remain competitive, organizations across industries and countries pursue innovations [Bau02], [CGM+16], [TB18]. Staying ahead of competition due to being innovative is deemed beneficial for several reasons, e.g., to gain Schumpeterian pioneer advantages [Sch06], a positive image for marketing purposes, or heightened attractiveness as an employer [JMD12].

In addition, the digitalization changes the business landscape dramatically [BM16] and results in new opportunities to foster innovations with unprecedented pace [LMR17], e.g., building up industry-wide platforms (for an overview [Mül22]). Common outcomes of this trend are process innovations relating to organization internal operations (e.g., improving auction operations [TB18]), digital services surrounding existing products (e.g., predictive maintenance services; see in general [BDP+15]), or collaborations in the form of interorganizational service networks (e.g., the way Bosch acts as a supplier and service (network) provider for different industries [Mül15]).

Bearing these observations in mind, it is striking that the managerial debates in practice and theory primarily revolve around product and service innovations [TB18]. Though of increasing interest across industries [AHR+15], business model innovations are rather seldom discussed from a science perspective. For the purposes of this section, we relate to business model innovations as changes in the underlying logic and operations of an organization and its environment [OP10], [ZA10]. A frequently cited example for business model innovation is the streaming platform Netflix. The organization started as a service for renting DVDs in the USA by mail. Soon after its inception, Netflix did not charge its customers anymore on a pay-per-use-basis, but started to charge them on a subscription basis. About ten years later, Netflix changed its course again, offering streaming services that are by now globally available. Though having a large customer base and being a prime example, in terms of profitability challenges remain ahead for Netflix. This also applies to other frequently hailed business models, such as those of Airbnb or Uber. Against this background, it becomes obvious that future research and managerial practice still need to elucidate the multifaceted phenomenon of business model innovations in light of digitalization—not only, but also in the field of digital farming (for practical perspectives in this regard see [TA17]).

The present section's objective is to address the aforementioned managerial and theoretical void by offering insights into business model innovations as a distinct innovation form that is of utmost importance in light of digitalization with special emphasis on Digital Farming.

The section is structured as follows: First, we introduce business model innovations as a distinct form of innovation and elaborate upon the business model canvas as a managerial tool and apply it to the digital farming setting, illustrating our idea against the backdrop of [Xar20]. Thereafter, we discuss the managerial implications and conclude with a summary, critical reflection and outlook for future research as well as managerial practice.

2.5.2 Business Model Innovation as a Distinct Form of Innovation

Despite being a comparatively young discourse, within the managerial debate about what makes up a business model, definitions are abound. One prominent definition by [AHR+15] suggests a value-based approach, focusing upon the value created for the customers, how the value is delivered to the customer, and finally how much value is captured (i.e., the amount of revenue that an organization receives for its part in providing an offer). Along similar lines, Gassmann and colleagues [GFC20] deliberate who the target customers are, what is actually offered, how value is generated, and how the offering is produced. In contrast, [Tee10] suggests that it is decisive to analyze how a firm delivers value to customers and converts it into profits and [ZA10] (see also [ZA07], [ZA08]) lay emphasis on the fact that a business model transcends organizational boundaries.

In sum, one can identify no generally accepted definition. However, it is commonly agreed upon that business models emerge from interaction of components. Moreover, a business model offers a foundation for dynamic strategies for companies to achieve and contain competitive advantage ([AHR+15]; see also [LMR17], [MZB+18]).

Building upon these observations, business model innovations represent a novel form of innovation. Maybe the most prominent innovation forms are product innovations (e.g., the iPhone in the case of Apple; see [CGM+16] for an overview) or service innovations (e.g., online banking; see [BDP+15] for an overview). Business model innovations have gained increasing attention, though they are still less debated when being compared to product or service innovations.

As for business model innovation definitions, some authors stress that they relate to "two or more elements of a business model are reinvented to deliver value in a new way" [LRS+09], while others stress that "A business model improvement is any successful change in any business model element […] that delivers substantially enhanced ongoing sales, earnings and cash flow advantages versus competitors and what customers can supply for themselves" [MC04].

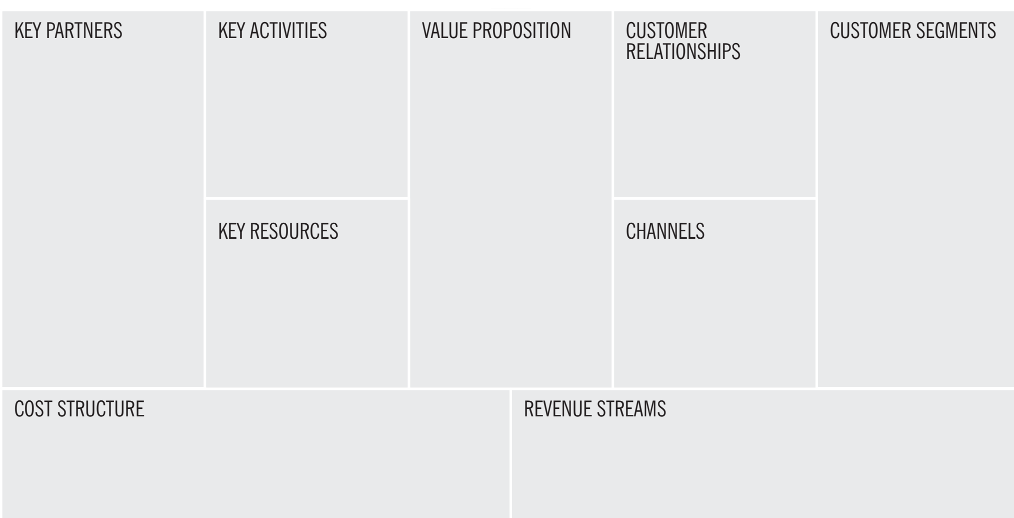
2.5.3 Business Model Innovation in Practice—The Business Model Canvas

Within the debate about business model innovations, there exists a broad range of tools for managerial practice. One of the most prominent examples is the so-called business model canvas, being introduced by [OP10]. In this connection, the authors define a business model innovation as follows: "Business model innovation is not about looking back, because the past indicates little about what is possible in terms of future business models. Business model innovation is not about looking to competitors, since business model innovation is not about copying or benchmarking, but about creating new mechanisms to create value and derive revenues. Rather, business model innovation is about challenging orthodoxies to design original models that meet unsatisfied, new, or hidden customer needs" [OP10].

The authors conceptually build the business model canvas on ideas of how a value chain can be sketched within an organization as put forward already by [Por85] and the idea of the resource-based view [Bar91]. Porter's basic idea was to illustrate the flow of input, throughput, and output within an organization and how this is related to overall performance. Barney suggests that an internal organizational resource can be the source of a sustainable competitive advantage, if it is valuable, rare, inimitable, and non-substitutable. These ideas coalesce in the business model canvas that offers an overview of organizational activities and can help to identify how an organization can generate value and capitalize thereupon; that is, setting the basis for a critical reflection of the status of the business model and offering a springboard for business model innovation.

The business model canvas consists of a reflection of the following elements (see ◘ Fig. 2.14):

- **Key partners:** This element relates to the most important collaboration partners of an organization. It stretches usually across the value chain, including suppliers and key customers of an organization. As is the case with any interorganizational collaboration, benefits (e.g., deriving economies of scale and scope) and risks (e.g., losing one's core competences) need to be carefully reflected upon [SSM16].
- **Key activities:** With regard to this element, a reflection is needed in terms of what operations add most value with regard to the existing or future business model. Towards this end, not only internal organizational operations, but also the input and output operations need to be considered. Also managing patents or trademark rights are viable other options to scale one's business model innovations (see also [CGM+16]).
- **Value proposition:** In terms of the value proposition, an organization needs to be able to define clearly, what value is being offered to customers. The value can be manifold, be it related to an additional service and data being offered, the reduction of a flaw, the prediction of errors, a gain in efficiency, or a gain in reputation to mention only a few options.
- **Customer relationships:** In this connection, key questions revolve around the way an organization deals with its customer base. Here, a key concern relates to the way customers are being integrated into the business model (e.g., think of the extreme integration of customers in the way IKEA customers usually assemble their furniture on their own in contrast to conventional furni-



◘ **Fig. 2.14** Business Model Canvas, source adapted from [Str20] ture stores). The relationship can vary. For instance, it might be the case that you have close interpersonal ties as in the case of private banking where relationships can last for a lifetime. In contrast, merely transactional relations are also possible as in the case of buying an item at an online platform such as Amazon or Alibaba.

- **Customer segments:** Analyzing an organization`s customer base along different segments offers the possibility to prioritize customers. A consequence can be to (re-)align the key account management activities. Moreover, it is also possible to ignore customer segments that are not beneficial for the organization (e.g., because they harm the reputation of an organization or the value captured is insufficient).
- **Key resources:** The key resources of an organization describe the most valuable material as well as immaterial resources, such as personnel, machinery, data, fields, or factories. As pointed out above, here the ideas of the resource-based view are most evident [Bar91].
- **Channels:** With regard to channels, [OP10] target the relevant media by means of which the focal organization interacts with the customers. These types of channels can be differentiated along various dimensions. One dimension might be the customer life-cycle, e.g., making a distinction between the first customer touch points to after-sales services. Alternatively, one might make an analytical distinction between the exchange format, ranging from face-to-face communications to digital exchange situations supported by digital devices such as mobile phones or laptops and personal computers.
- **Cost structure:** The cost structure directs attention to the costs occurring for the different parts of an organization's operations. Towards this end, [Str20] suggests reflecting upon, among others, the resources or the activities that cause the highest costs to come up with suggestions on how to curb down costs.
- **Revenue streams:** Reflecting upon the revenue streams is informative in many ways. For instance, valuable insights might be generated from differentiating between one-off (e.g., in the course of a single transaction) and continuous revenue streams (e.g., in the course of a subscription model as in the case of streaming services, such as Netflix). In addition, checking customer preferences might be beneficial, e.g., in terms of the customer's willingness to pay, the (digitally supported) payment options, or how the different value streams contribute to the overarching financial results.

Bearing these elements of a business model in mind, we would like to apply it to the digital farming setting based upon an example of a farming-related app, such as that of [Xar20] being offered by BASF:

- **Key partners:** BASF needs to consider the farmers, which represent the final customers or at least final beneficiaries of xarvio. Depending upon the specific setting, BASF also cooperates with a corporation for AgMachinery and original equipment manufacturer corporations (e.g., Bosch) and retailing corporations. Finally, public institutions might also be key partners in the foreseeable future as they oftentimes provide freely available data (e.g., with regard to weather forecasting the Joint Research Centre of the European Commission).
- **Key activities:** Visualizing and analyzing data are the essence of such products. They are capable of analyzing data generated from different sources and systems to come up with novel business model opportunities. That implies that farmers adopt the role of data providers (i.e., suppliers) while at the same time being customers who shall buy the

products. Additionally, activities need to be aligned (especially technological interfaces) with collaboration partners of AgMachinery. Finally, providing a cloud or making use of cloud services of another company might be another critical key activity. As a result, interfaces need to be organized and can be further developed (see along similar lines with regard to cloud services in a farming setting: [TA17]).

- **Value proposition:** Farmers will be supported in the management of their fields, in effect improving their crop management, reducing costs and risks (see ▶ Sect. 2.3). For instance, farmers are able to make use of the app to check a specific disease of their plants by taking a photo of a plant being affected and immediately request advice what crop protection product is necessary. Another service that comes handy might be fertilizing the fields as precisely as possible based upon a close data exchange between the aforementioned parties involved, e.g., AgMachinery companies. What is more, positioning sustainability as a further value to be promoted is another instance. Take for instance the so called "Lerchenbrot" (lark bread), a joint activity by BASF and other partners along the value chain up until the final consumer including the bakeries. In this case, the companies collaborate to jointly safe breeding grounds for larks (provided by xarvio/BASF) and nonetheless benefit also financially from the activity while being able to derive higher profit margins for the final product, the larks bread at the bakery.
- **Customer relationships:** The relationships to be managed are likely to be rather transactional insofar as the app might be offered for farmers around the globe. However, to a certain extent a community might be built up in terms of a Q&A forum integrated into the respective app. However, market access can also take place via other stages of the value chain, e.g., food producers or traders.
- **Customer segments:** As pointed out, the primary customers are farmers and contract farmers. They might be divided into different segments, e.g., depending upon their production philosophy, machinery brands used, or crop rotation.
- **Key resources:** Key resources comprise software and technology development teams as well as the necessary related financial resources. Moreover, having data available for analytical ('big data') purposes represents another key resource. To put it differently, this relates to the ability to connect with multiple market partners and establish sustainable business models.
- **Channels:** The digital products represent the primary medium for interacting with the farmers. Hence, digital channels dominate. In this case, a multi-channel approach is deemed suitable, so that customers can be approached through different channels depending on the country.
- **Cost structure:** Data center investments, app developers, and the customer support services might account for the largest cost chunks. Over time, customer service might be outsourced to a chatbot and others solutions in parts where possible. That is, if the gathered data is substantial enough so as to offer adequate big data generated insights from farming operations.
- **Revenue streams:** In terms of the revenue streams, farmers pay for the app on a subscription basis. However, a freemium represents the starting point with regard to some functionalities so as to entice customers.

2.5.4 Reflections on the (Mis-) Use of the Business Model Canvas and Conclusions

To sum up, reflecting upon business models and business model innovations seems to be a key managerial concern, not only, but also in particular due to the digital transformation [LMR17]. Against this backdrop, the business model canvas turns out being an easy-to-use managerial tool that helps managers to reflect the different elements of a business model and—if changing its elements—business model innovation.

The popularity of the business model canvas can be traced back to several advantages: The canvas is easy to visualize and, thus, easy to use and convey information ensuing from the canvas. Moreover, it covers the key issues making up a business model and, depending upon the specific needs, data to be analyzed and the ensuing discussion regarding potential implications can vary in mass-customized fashion. This is also particularly attractive insofar as the agricultural sector appears being in many sectors a commodity market, where business model innovations targeting higher product segments and alternative market access is a valid—albeit difficult to achieve—strategic option for farmers and Ag market segments (e.g., focusing on old varieties, specialty products, co-production systems like agricultural-energy-farmers, see ► Sect. 1.2). An externality effect such as the European Green Deal (see ► Sect. 1.6) might result in further threats and opportunities for actors in industry as it is most likely to entail novel dynamics and altering value chains, which in turn result in new business model opportunities awaiting further exploration and exploitation (e.g., biodiversity, carbon market).

Nonetheless, the business model canvas is not without limitations. Apart from its static nature—owing to the observation that it heavily relies upon the eclectic consolidation of static conceptions, such as that of [Por85] and [Bar91]—it does not offer any advice on how extensive data collection and analysis shall be. Moreover, the elements are partially overlapping, making the decomposition oftentimes problematic. Finally, due to its intra-organizational focus, the organizational environment is by large neglected: For instance, the competitive landscape, societal or cultural factors or in light of digitalization the collaboration across organizations. Thus, future managerial practice and business model research might consider taking a look at business model generation and innovation on the whole network level of analysis [PFS07], that is, how business model innovation might unfold on the level of interorganizational networks [MZB+18], [Thi19]. This might comprise cloud services (for a practical discussion see [TA17]) or other platform operations [GC14]. Given the networked nature of (digital) farming, this topic awaits further exploration, incl. requirement definitions in initial business model versions or minimum viable business models.

2.6 Accelerators & Partnerships: Anticipating the Unknown is Hard: An Experience Report

Borris Förster

Abstract

The sustainable production of food is one of the most complex and pressing challenges of our time (see ► Chap. 1). The traditional food value chain across all actors from input companies through to retail is facing unprecedented pressure through environmental, demographic, societal and regulators trends. These trends will lead to significant structural changes over the forthcoming decade on the products consumed and how they

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are produced and moved through the supply chain. The food supply chain will change substantially, and this in turn will affect the way business is done and value is created. Some segments and its constituent intermediaries in the value chain will cease to exist for obvious reasons and others will change in the way they operate and what they produce today. Incumbents are scrambling to deploy a variety of innovation measures to confront the change with varying degrees of success.
In this section, I will give an insight into the conflicts of interest and associated challenges within much hailed acceleration and corporate partnership programs. I endeavor to provide my view and personal experience on the current landscape and where we need to head in terms of foundations and backbone infrastructure to move faster and more efficiently towards the future of farming and food production. Partnerships, co-development and new industry players will have to play a significant role to leap forward in the industry. We need to re-think collaboration.

2.6.1 Introduction

Predicting the future is a tough task, being right even tougher. This is essentially what incumbents are trying to do, when launching accelerators, corporate venture capital vehicles, start-up partnership programmes and the like. The real challenge, however, appears frequently misunderstood. To stop extrapolating the current core portfolio and instead start thinking in terms of future operational environments and to target actions accordingly in combination with available assets and likely future customer needs (see ► Sect. 2.5).

Figure 2.15 depicts a French farmer in the year 2000, painted by Jean-Marc Côté. It stems from a series of artworks issued in France between 1899 and 1910 showing the view of the future of farming in the year 2000. As is often the case, the predictions fell some way off the mark, failing to go far enough in thinking outside the confines of their current technological milieu. We tend to under- and over-estimate the changes in the future as we extrapolate our personal experience into the future, instead of putting our focus of thought on predicting probable future environments to derive solutions that will be necessary to operate under those conditions. So, when embarking on new paths to build solutions and new products in partnerships or advancing early start-up companies through accelerator programmes, incumbents must ensure they focus on a vision of the future industry operating environment instead of a specific outcome and extrapolating todays “ways of doing things”. This proves especially hard for established businesses as the majority of their operation is geared toward preservation, prolonging product lifetime, and incremental innovation.

To cope with this uncertainty, incumbents require a clear vision to build upon. In order to do so, first, we must understand agriculture and food as one single supply chain that it is not linear, but looping back at several points. Secondly, we must understand the basic requirements to support and grow innovation in different contexts.

The digital transformation of agriculture, food production and supply is perhaps the most complex challenge of our time and thus requires joint efforts across multiple disciplines and actors. The route to successful new solutions is full of pitfalls in terms of problem-solution and solution-market fit in the first place. Today’s incumbent actors, while mostly intending to foster and support new solutions through accelerators, corporate venture capital and partnerships fall short on delivering on their own expectations. In fact, experience

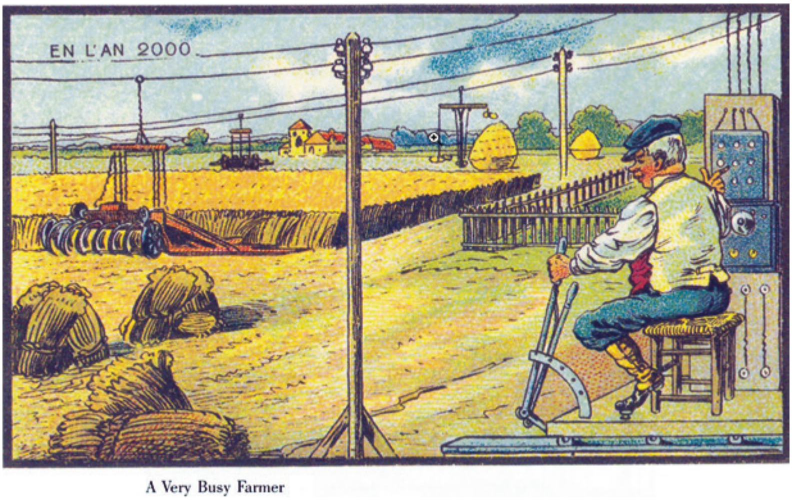

Fig. 2.15 "a very busy farmer" by Jean Marc Côte [Cot10] (cropped)

has shown established companies frequently compound the challenges, making it harder and overestimating their ability to accelerate at the current point on their transformational roadmap. To make significant leaps forward collaboration and exchange across and within value chain segments must increase drastically.

To get there, current thinking requires a change of direction: away from owning 100% of a small pie towards enlarging the pie for everyone. We need to understand why and how to create equal partnerships between unequal partners. We need to kill pet start-up projects and accelerator programs that are not delivering or become unlikely to deliver real value to the goals of the organization and the supply chain at large, sooner rather than later. We need to start treating start-up-us like companies and entrust them with paid projects for grown-ups, instead of grants and special programmes treating founders as hobbyists and enthusiasts. This, however, necessitates that the goals and vision of the organization are clear and commonly understood by all actors—which often it is not.

2.6.2 Understanding and Managing Direct and Indirect Impact on Success—Borrowing from Physics and Finance

To understand the workings behind success and failure of accelerators and fruitful partnerships, it helps to understand what you are up against. Three at first sight unlikely concepts lay the groundwork to give direction and prepare the field before sowing:

1. Newton's Laws of Motion [Bri20a],
2. Newton's Law of Universal Gravitation [Bri20b],
3. "Modern Portfolio Theory" or in other words the risk-averse behavior of investors [Mar52].

2.6.2.1 Newton's Laws: What Physics can Teach us about Accelerators & Partnerships

Let us understand the basics of Newton's Laws of Motion and Universal Gravitation to make better decisions. Starting with motion:

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Newton's First Law of Motion "A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted upon by an external force." [Bri20a, Bri20b].

This simply means that things cannot start, stop or change direction all by themselves. It requires some external force to cause such a change.

Newton's Second Law of Motion "The acceleration of an object increases with increased force and decreases with increased mass". It also states that the direction in which an object accelerates is the same as the direction of the force." [Bri20a], [Bri20b].

Assuming constant mass means in order to accelerate an object a force, it needs to be exerted upon the object. Moreover, the direction of force exertion is equal to the direction of acceleration.

Newton's Third Law of Motion "For every action, there is an equal and opposite reaction". [Bri20a], [Bri20b].

In other words, whenever two objects interact with one another, they exert forces on each other.

In summary, objects in the physical world do not move of their own accord. Nor do they in economics and business. Within the context of innovation and building new businesses, this notion provides a fundamental understanding and scaffolding for success. No business starts without the deliberate application of a force, i.e., action. This, by the way, is also the reason why good ideas by themselves are worthless, if they are not acted upon. It needs concerted action and execution. The entrepreneur or intrapreneur provides this initial action to identify a need, derive a solution and business model, test and build it. In its absence there would be no new businesses. In fact, there would be no economy as we know it today. Moreover, only the continued effort of the entrepreneur, employees and other stakeholders will keep things moving. This is important, because in business, operations rarely maintain their level; much less grow by themselves. In fact, the opposite is true. There is always friction in the business environment: interest rates and terms of contracts change; competitors enter the market; economic volatility affects demand and so on. Consequently, things tend to decay over time if we stop acting. Revenues drop off and costs increase. The bottom line erodes.

The larger the business, the more entrenched its bureaucracy, the greater the mass you are pushing against. It requires the application of extraordinary energy to get it to move even a small amount. Often, the easiest course of action is simply to do what you are doing. Everyone knows the routine. Generally speaking, no additional expenditure of time, effort, or money is required. It feels familiar and comfortable. It is only when someone seizes the initiative and takes an action that things change.

Translating the laws of physics to the world of corporate start-up partnerships and accelerator programs brings some fundamental problems to light. In order to accelerate effectively, i.e., wasting as little energy as possible, the common direction of acceleration must be known to all parties and aligned by all parties exerting force. In the context of corporate accelerators and partnerships this leads to a dilemma if the vision and strategy of the corporate is not 100% clear and aligned with the start-ups and partners (remember: a clear corporate strategy is important). Furthermore, the direction and size of the force exerted is heavily influenced by corporate politics and the agendas of individuals, which in turn is influenced by corporate culture.

Once direction is aligned between parties, the focus shifts to the force to be exerted in order to accelerate or at least keep it moving at the same speed, not slowing business down. This is where corporate acceleration and partnership programs tend to exaggerate their abilities. Experience shows, because actors heavily underestimate the effect of their own size, direction of movement and misalignment on strategy and vision within their organization. At the same time, actors tend to overestimate transferability of know-how and the required motivation and competence within their own organization. This brings us to the last key learning from Newton in regards to transformation through accelerators and partnerships, pulling it all together.

Newton's law of universal gravitation "every particle attracts every other particle in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers" [Bri20a+b].

In other words, attraction between objects is subject to two variables: mass and distance. Taking Newton's laws of motion into account this means that the object with the larger mass will be a greater influencer on the direction of the smaller object than vice versa.

The tendency of an object to resist changes in its current state of motion varies with mass. Hence, the more massive an object, the greater its tendency to resist changes in its state of motion. The same is true for businesses. It indirectly asserts that the force to change direction must be much larger on a big organization than on smaller start-up company.

This effect, unaccounted for, can be detrimental for the relationship and result in losing the optimal trajectory (i.e., roadmap and strategy) desired by the start-up management and the corporate supporter. Imagine SpaceX miscalculated the mass of the earth and thus its gravitational force when shooting a rocket into space. An underestimation would pull the rocket back down toward earth and never reach its actual destination.

Lastly, Newton's Laws offer one potential explanation of why we do not find much quantitative evidence today that the general speed boat doctrine of digital and innovation gurus globally is panning out as prophesied. Visualizing the concept, it would either need dozens of speed boats (business pilots and start-ups) moving in exactly the same direction to eventually move the ship (a sizeable organization) or a speed boat that has already matured into the size of a tug boat, once you bring it back closer to the parent company.

2.6.2.2 Modern Portfolio Theory: How Investors Think and Act

Modern Portfolio Theory shows that an investor can construct a portfolio of multiple assets that will maximize returns for a given level of risk. Likewise, given a desired level of expected return, an investor can construct a portfolio with the lowest possible risk. Based on statistical measures such as variance and correlation, an individual investment's return is less important than how the investment behaves in the context of the entire portfolio. [Mar52].

Continuing the speed boat example, this means that dozens of speed boats moving into exactly the same direction to move an organization would leave investment risk skyrocketing. It would substantially defeat our understanding of modern portfolio theory guiding large organizations today.

In an ideal world, business would be run like a group of independent boats and ships including speed boats (new opportunities), fast ferries (growth stage commercialization) and tankers (the cash cows of the core business). Each boat is given an equal chance to grow into a tanker and sufficient independence. If successful crews are moved around, added and withdrawn as necessary and we slingshot smaller businesses through the fleet in order to grow faster utilizing existing assets.

Modern Portfolio Theory assumes that investors are risk-averse, meaning they prefer a less risky portfolio to a riskier one for a given level of return. This implies that an investor will take on more risk only if he is expecting more reward. The expected return of the portfolio is then calculated as a weighted sum of the individual assets' returns. This in turn assumes that the desired level of risk and return is known and well understood by all. Experience and data on corporate accelerators and innovation returns has shown that this is not the case in many organizations. More often, there seems to be a distinct discrepancy between the accepted risk and the desired returns. The relatively low risk appetite among companies in Germany, compared with our anglo-saxon counterparts, has to do with our past and industrial systems. Germany is a world leader at selling units of physical products with exceptional quality. Once a unit is sold that same unit cannot be sold again. This is different with digital products, i.e., the potential return and marginal cost function is different and often seems not well understood by major stakeholders.

In conclusion, theory and evidence suggests that long-established businesses are losing the competencies and drive is required to build and scale business due to their long-standing position of relative strength in a given market. They are organized to keep the business running, mending, maintaining, and incrementally growing or securing the existing business. They understand their playing field exceptionally well and the effects that sizable competitors have on their core KPIs. But they underestimate the effort, organizational setup, transparency, resources, strategic clarity, and vision necessary to gain positive returns on invest from partnerships and accelerator programs.

The first two (Newton's laws of motion and gravitation), translated to business, will impact your accelerator portfolio and partnerships in terms of development, commercialization speed, and success toward significant returns. The third (Modern Portfolio Theory), will, to a large extend, affect your freedom and resources to operate as a practitioner, leading innovation and transformation programs in an organization. Though I have rarely experienced any arguments against the applicability and importance of these forthcoming ground rules as a framework for operational execution, understanding the negative implications, if ignored has frequently been met with surprise and disbelief in executive boards—until they shut initiatives down.

For clarity, employees, business owners, partners, or anyone else spending time on the business in partnerships or within the accelerator and other innovation initiatives are in fact investors. And they need good and sustainable incentives to move towards the right and the same goals.

2.6.3 The Current State of Technology in the Food Value Chain

Technological innovation, ever stricter regulation and global challenges and trends are putting significant pressure on the dynamics of the traditional food supply chain (see ► Sect. 1.2). New entrants are challenging the market share and growth prospects of settled incumbents with advanced biology, technology and new foods and challenging the status quo of the supply chain. Traditional farm production is squeezed in the middle between global oligopolies trying to protect their markets and novel high-tech food company entrants are skipping the traditional chain from grower to food company and in some cases even retailers altogether.

The AgFood sector has seen a significant rise and venture capital investment (corporate and private) and the number of corporate accelerator programmes has been mushrooming over the past years. In fact, venture capital invested in AgFoodTech including accelerator programs has grown by 32% CAGR between 2012 and 2019 to a total of EUR 17.8bn according to Agfunder [Agf20]. Currently, the largest part of the investment is circumventing Europe. This is partly due to the fact that two of the main tech trends are driven by developments in genetics and AI. Two things, to say the least, that face severe obstacles in the EU from an international perspective. However, in the long run, technology will change farm operations and the entire supply chain radically, also in the EU. This will have significant effects on the supplier industry. The question is, will incumbents in the EU be a driver and benefactor of this change or fall victim to progress in other parts of the world. The EU Green Deal may pose a regulatory opportunity to set European companies on a path of future competitive advantage, if they see and cease the opportunity (see ► Sect. 1.6).

Already today the fight for vertical control, integration and circumvention of previously established segments in the food supply chain is on. The pressure from upstream incumbents like retail giants is mounting as they push to gain deeper control of Upstream production to reduce costs, increase efficiencies, and deliver to consumer demands at low prices. At the same time, input companies are developing "X-as-a-service" and guarantee-based business models to build new future-proof business. The up and downstream pressure is concentrating at the farm production level.

Traditional food supply takes place in a highly complex linear supply chain (see ◘ Fig. 2.16) with mostly product-driven players, comparatively low R&D intensity and low efficiency (hard to optimize holistically, leading to high wastage) in which each segments' performance is dependent—at least in part—on the level of technological capability, transparency and efficiency of the previous segment. Upstream agricultural production is perhaps the most complex segment. It is the least transparent, least digitally enabled, least technologically integrated chain-link [Mck20] and is highly exposed to unforeseeable circumstances. This vulnerability circles back on the rest of the value chain creating a butterfly effect, with ever-increasing uncertainty and unpredictability.

The status quo is preventing the scalable deployment of digital & physical services and applications, because such are dependent on information and feedback from other participants. This problem has been one of the drivers for the increasing trend to vertically integrate. This makes acceleration of digital solutions difficult, especially the one relying on information flows from different parts of the supply chain.

To counteract the described changes in the supply chain and future operating environment, incumbents have ploughed significant resources into start-up innovation initiatives like accelerators with limited success. According to estimates from Doblin innovation consulting [Dob19], 96% of all innovation initiatives—across a selection of major industries—fail to make a return on investment.

As described earlier, large organizations are generally slow-moving, process-driven and risk-averse. They are optimized for stability and preventing failure by tackling incremental projects. But to innovate and "accelerate", you need to move fast, often ignore process and take substantial calculated risks. This requires an organizational setup geared towards the testing of ideas and accepting failure as part of the game. The cultural shift that is necessary is often the biggest impediment to achieving success. Acceleration programs setup as a side show in fancy office buildings with bean bags and tabletop soccers were supposed to get around these obstacles. However, this will not work by itself. The organization has to provide a compelling value proposition to start-ups and partners, be able to deliver on it and ensure strategic alignment.

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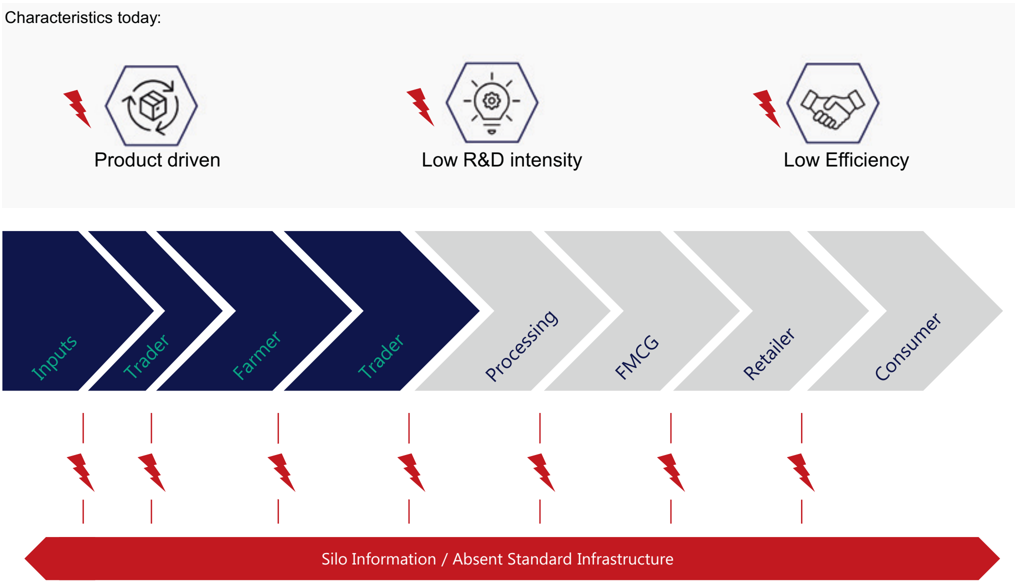

Fig. 2.16 Inefficiencies in today's AgFood value chain

A frequently used indicator of success for accelerator programmes and Corporate Venture Capital (CVC) units is the number of partnerships between the big companies and the start-ups post-investment or after the corporate accelerator program. According to research from CB Insights [Cru19] on corporate innovation across all major industries, only 10% announced a formal partnership after CVCs invested (see Fig. 2.17). Accelerators only announced partnerships with participating companies 1% of the time. That is only 1 in every 100 start-ups. With the usual two annual batches of 12 start-ups it would take more than four years and several million Euros to form one single partnership.

Organizations are acting and quietly shutting down programs or cutting budgets as their success stays behind expectations. In fact, 60% of corporate accelerators shut down within two years and one-third of new corporate venture capital activities stopped investing after five years [Cru19].

Corporate accelerators, start-up partner programmes, and venture investment today need a combined vision and the determination to move the needle. Experience has shown that frequently agriculture dedicated innovation vehicles think too small, are too internal-faced, ill equipped, led by people with expertise in areas that do not match the task at hand, and are too dependent on and involved in day-to-day corporate politics. Incentive and budget structures are not geared toward supporting risky and time intensive start-up acceleration and partnership projects with uncertain outcomes.

2.6.4 Looking Ahead: From Stand-Alone Programs to Multi-Corporate Innovation Platforms

In order to solve the challenges ahead, we need to move toward interconnected food value chains and accept that the roles of incumbents within the segments will change over time. Innovation initiatives like accelerators and partnership programs can be part of the foundation, if the influencing

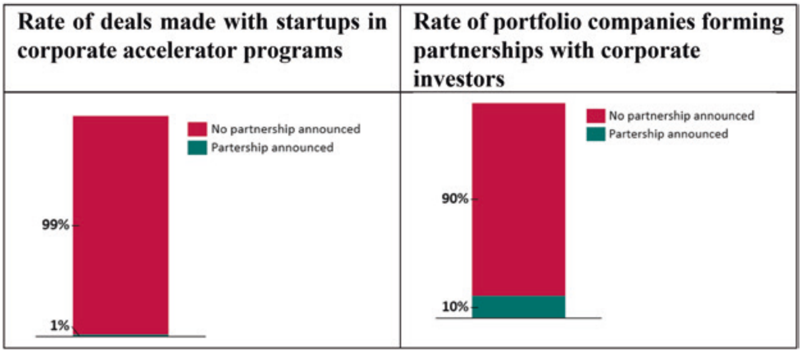

Fig. 2.17 Start-up deals and partnerships with corporate ventures [Cru19]

factors are well understood. We have to recalibrate collaboration across the entire supply chain.

Solutions developed by start-ups today can, to a large extent, only unfold their true potential if the right data is supplied to and by them to the adjacent segment at the right time to make actual decisions and later guide and activate physical actions on fields, handle farm logistics, and improve the efficiency of the wider food supply chain (see Fig. 2.18). It is about enlarging the pie for everyone.

Business models are changing from product driven to service and results driven offerings. The required industry infrastructure to support the business model evolution, however, is not yet in place. This is slowing transformation, cost-effective development, adoption and monetization. To enable the orchestrated deployment of connected services and applications in concert this must change to-

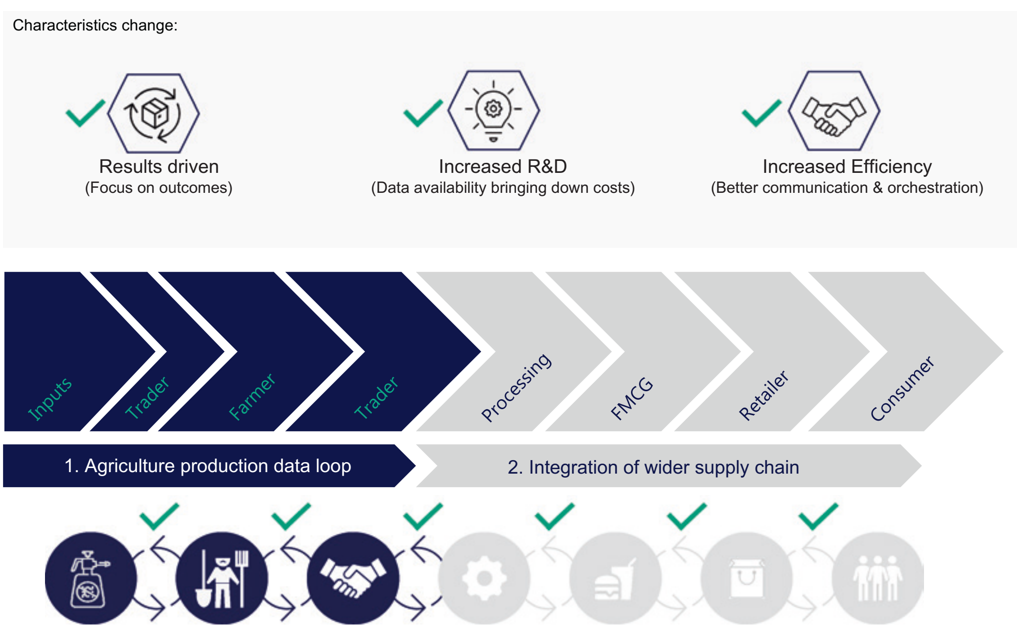

Fig. 2.18 Necessary changes to the AgFood value chain

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wards an open collaboration platform for multiple players, start-ups, and corporates alike.

To be successful, incumbents should provide their cohorts and partners with an Unfair Advantage to build and deploy their services and solutions across the Ag-Food supply chain. Help to connect the upstream and downstream value chain allows direct interactions from retail to farm inputs. Enabling all participants to build, test, deploy, and scale business models with their cohorts, in start-up partnerships and with their corporate venture portfolio. So future and current programs would do well to join forces with adjacent incumbents along the value chain to create innovation ecosystems together acting as a foundation for multi-corporate acceleration programs, innovation labs, start-up partnerships and company builders. This would be a true game changer.

Lastly, the way organizations are setting up their initiatives takes into strong consideration where they currently are on their digital and cultural transformation journey. It has to be clear what can truly be provided to start-ups and partners to create an Unfair Advantage. Initiatives need to follow a clear vision, be joined closely with corporate strategy, if early on in the transformation. In a constantly changing AgFood value chain (see ▶ Chap. 1), it requires a softer approach on execution and roadmaps to successfully correct assumptions and successfully position in the AgFood transformation.

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