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Vertical Integration of Digital Platforms in the Agricultural Industry

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Abstract

Vertical integration is a strategic option for a company that aims to have direct control over its value chain. With regards to digital platforms, vertical integration as a strategy is, to an extent, paradoxical, since platforms' operating models are largely based on external actors with whom the platform owners have only an arm's-length relationship. Many large digital platform companies have pursued vertical integration and research has been conducted on the subject, yet it is often industry-agnostic and focuses on large digital platform companies. We sought to identify the vertical integration strategies of digital platforms in the agricultural industry, as well as understand the firm- and industry-level drivers behind them. The results showed that these drivers impact vertical integration of digital platforms, which occurs along the value chain of a platform's user groups and not solely along that of the platform. Furthermore, digitalization and data open new avenues for vertical integration.

1. Introduction

Vertical integration, which can be explained as directly controlling the different parts of a company's supply or value chain, is one of the fundamental strategies for business growth [1]. Although the core idea of internalizing activities along a company's value chain is simple, the underlying managerial decisions are highly complex, due to the involvement of numerous interdependent factors [2]. Traditionally, vertical integration has been applied and studied in the context of industrial companies [3, 4], with one of the central questions being how much of the company's supply or value chain should be controlled directly by the company itself and what should be left for external actors [5].

Digital platforms differ from traditional pipeline businesses [6] in that they typically rely on external actors to deliver key assets and create content, instead of these processes being controlled by the platforms themselves. Therefore, pursuing vertical integration in the context of digital platforms poses somewhat of a paradox, since platforms are often seen as an alternative for vertical integration activities [7]. The key task for governing digital platforms is to manage transactions and contributions from third-party actors with which the platforms only have an arm's-length relationship [8, 9]. As a result, the platforms have only indirect and limited control over these actors through platform governance mechanisms [10].

However, many platforms engage in vertical integration as they seek to grow and expand their businesses. Several major digital platform companies, such as Amazon and Apple, have pursued vertical integration, through acquisitions in areas closely linked to the functions of their own platforms [11, 12]. Such expansions, however, are complex, as they occur in an intertwined activity network and in a structure where the direction of exchange is less linear than that in traditional value chains. The key objective for vertical integration (i.e. controlling the value chain), has also been discussed in the existing literature on digital platforms. For example, Ghazawneh and Henfridsson [9] reported that, in addition to transferring design capabilities, platform boundary resources function as a tool for platform owners to control the complementarities built upon the platform by external contributors.

Overall, the subject of boundary-setting in digital platforms (i.e. when and how to expand the platform's boundaries to new areas and functions) has attracted the attention of researchers [13]. However, research on the subject has mainly focused on major digital platform firms such as Apple and Facebook. At the same time, companies from more traditional industries such as agriculture, which included pipeline businesses with relatively clear supply and value chains, are also increasingly developing and launching digital platforms to support and expand their operations, as well as diversify their business models [14, 15]. In these industries, digital platforms are built on top of existing value chains by both incumbents with established market positions and start-ups entering the market.

As the extant research has primarily focused on major digital platform companies, firm- and industry-level factors influencing the vertical integration of

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digital platforms have not been explored. The aim of the present study was to fill that gap in the research by 1) studying the vertical integration of digital platforms within a specific industry and 2) including examples of start-ups and incumbents. The agricultural industry is an example of a traditional industry with evident industry-specific characteristics, including well-established value chains. At the same time, digital platforms have emerged within the agricultural industry and are creating new ways of delivering value to their customers. The research question posed herein was as follows: *What vertical integration strategies are being used by digital platforms operating in the agricultural industry?*

2. Vertical integration

Vertical integration is commonly defined as substituting market exchange with internal exchange [4]. While internal exchanges in manufacturing firms are typically unidirectional and occur between sequential pairs of internal activities [16], in digital platforms that are characterised by large networks of interdependent activities [17], internal exchanges can be bidirectional and occur between a combination of multiple non-sequential activities. This complexity renders many of the internal exchanges unlikely to be present at external markets; therefore, vertical integration is more than just substituting market exchange with internal exchange. In addition, it has been previously reported that the exchange needs to occur between activities that are dependent on each other [1, 16], which are also referred to as unique complementarities [18].

In this study, vertical integration of digital platforms was defined as *acquiring distinctive, unique complementary activities under a company's direct hierarchical control and developing internal transaction networks while substituting market exchange*. This definition emphasises the role of complementarities rather than directly referring to supply and value chains; that is because activities and their complementary relationships have been identified as an appropriate unit of analysis in the domain of digital platforms characterised by networked activity structures [18].

Strategic management research on vertical integration has been shown to vary between firm-level managerial aspects of vertical integration decisions [19] and industry-level studies analysing the relationship between vertical integration and specific industry characteristics or practices [20]. While the interdependence between the two approaches is generally acknowledged in the literature, studies have usually only focused on one or the other [19].

Digital platform research has focused on other types of expansion strategies, such as platform envelopment [12], and entry into complementary [21] and new platform markets [22]. The focus of these studies was primarily on horizontal integration, the complementarities provided by external actors, entering new markets or attracting more users to the platform.

2.1. Drivers of vertical integration

The extant economics and management literature on the drivers of vertical integration can be divided into three streams. The first stream is focused on efficiency and grounded on the transaction cost and property rights theories [3]. The main argument is that, by internalizing the transaction, the related transaction costs are also eliminated.

The second stream has focused on firm capabilities that increase or limit a firm's ability to perform certain downstream or upstream activities. These capabilities are understood as configurations of assets, resources and activities [23] that create efficiencies and quality advantages over other firms [24]. The capability perspective suggests that vertical integration allows for performance advantages by expanding opportunities for systemic internal innovation and access to technology and information [25]. However, it also simultaneously risks foreclosing external innovation opportunities and reduces strategic flexibility, as compared to relying on the market-based capability acquisition [26].

The third stream of literature has focused on the ways in which vertical integration can influence market power. The main argument is that vertical integration contributes towards a firm's ability to control market prices by adjusting supply and demand [27] and bargaining power by impacting price, quality and relationships between the firm, and buyers and suppliers [4]. Vertical integration can increase a firm's market power by, for instance, offsetting the bargaining power of upstream suppliers or downstream distributors [4], building entry and mobility barriers [27], or increasing differentiation [16].

2.2. Industry-level factors impacting vertical integration of digital platforms

In addition to firm-specific factors, industry structure and characteristics (i.e. standards, complementors and stakeholder groups), as well as information flows, have been found to influence vertical integration [4] also in the context of the digital platform boundaries [13].

Standards are technical specifications that can be categorised in different ways [28]. Component standards enable the same components to be reused in

multiple products [29], while interface standards allow compatibility and interoperability between products or services [30]. Modularity, that is, utilizing separate components that can be assembled and recombined to create a new system, increases the importance of standardization, since mapping functions to components makes the components more reusable and less interdependent [29]. Platforms are characterised by modular interfaces, which enable them to reduce coordination and transaction costs [31]. Therefore, operating in an environment that widely utilises standards and modular architecture may reduce the need for vertical integration, since the interoperability of different capabilities is more likely, even beyond a firm's boundaries [20]. However, in the case of systemic innovation, which is the simultaneous adjustment of multiple components in a system's value chain, vertical integration is often used to achieve control over activities with no new standards yet in place [32]. Setting standards requires the ability to influence other industry members, something that weaker players, such as start-ups, rarely have [21]. Moreover, the standard-setting ability offers control over technological trajectories and increases the market power of the standard-setter [12].

Relationships with complementors and other stakeholder groups form another element of a platform's vertical integration strategies. A complement is a product or service that adds value when consumed or utilised together with another product [18]. Platforms often use external innovators for the development and production of complementary products, services and technologies [33]. Thus, the question of what to acquire from complementors and other stakeholders and what to manage and directly control internally has proven pivotal, both in strategic management and digital platform literature. Related to complementors are the different stakeholders that are interdependent on a firm's business [34], including suppliers, customers, distributors and standard-setting agencies. Generally, the presence, power and relationships among these groups depend on industry context and structure [34], and therefore influence platform dynamics, such as network effects [35].

Finally, information flows across the value chain are vital for the successful management of any firm's business. Lack of access to information flows leads to information asymmetry, which occurs when two exchange parties possess an unequal amount of information about the product or service under exchange, leading to uncertainty, adverse selection and moral hazard problems [36]. Vertical integration has been deemed as a strategy that can eliminate inefficiencies created by information asymmetry [37]. In the context of digital platforms, different kinds of feedback systems aim to reduce information asymmetry by enabling the exchange of quality information [38]. These systems, which involve data and feedback flows between the different actors residing on the platform, are a distinctive feature of digital platforms [6].

The identified firm- and industry-level factors served as a framework for the present empirical study of the selected case companies.

3. Methodology

Our empirical research focused on the agricultural industry, as it is an industry with relatively clear value chains. Simplistically, one company produces machinery, another provides seeds and pesticides, and a third one buys the crops from the farmer. Second, while the industry includes several well-known and well-functioning companies, such as machinery manufacturers, it has also started to attract start-ups, highlighting the potential for innovation in the industry. Third, agriculture is an example of a truly global industry.

A qualitative longitudinal multiple case study approach was adopted for the research. The corpus of our empirical data was compiled using publicly available sources and includes a pool of >1,100 documents, with a final sample of 403 documents. First, company blogs and press releases were used to build an event timeline and identify vertical integration arrangements for all four case companies. A detailed description of platform evolution was available due to active self-reporting by the selected companies. Second, independent news articles and expert blogs were sourced from agricultural technology news aggregator AgFunderNews, which provided us with sufficient coverage on the selected case companies. Online blogs and news articles have previously been used as a data source in platform studies, as they provide researchers with valuable perspectives from the industry followers, as well as the people and companies involved in the industry [8, 39]. Third, both business and academic journals specializing in the agricultural industry were used for triangulation and to obtain a deeper understanding of the industry and its structure.

The selection of the case companies was based on four criteria. First, to ensure that all selected platforms were operating under a similar industry environment, the sample companies were required to operate within the U.S. agricultural industry and in a segment that serves crop farmers. Second, both start-ups and incumbents were included in the sample for this research. Third, the case companies had to operate platforms with at least two market sides. Finally, the case companies were required to demonstrate the successful execution of platform strategy using funding,

installed base or reported revenue as the criteria. As a result, two incumbents, i.e. Deere & Company (John Deere) and Climate Corporation (CC), and two start-ups, i.e. Indigo Ag (Indigo) and Farmers Business Network (FBN) were selected.

John Deere	CC	Indigo	FBN
97	150	107	73

Table 1. Number of documents per case company[1]

3.1. Description of the four case companies

Indigo: Founded in 2014, Indigo started as a microbiology company that developed coated seeds to improve yields, as well as make them survive harsher conditions and require less water and chemicals. The company also built a data-driven product development process for collecting, processing and analysing microbiology data. Building on these data capabilities, Indigo rapidly grew into a complete end-to-end solution provider for farmers. In 2018, Indigo launched a platform where farmers could sell their grain directly to food producers. It differentiated from numerous other marketplaces by using its data capabilities to measure farmers' grain quality and properties, enabling them to sell higher quality grain and special crops with a price premium. To support the marketplace, Indigo used vertical integration into services such as logistics coordination, warehousing, agronomic services and financing. In 2019, Indigo added support for regenerative and sustainable farming practices to its service portfolio. At the same time, it launched a carbon marketplace to facilitate trade between farmers sequestering carbon dioxide into their soil and businesses aiming to offset their carbon footprint.

FBN: Established in 2014, FBN started as an unbiased agronomic data integrator at a time when concerns over data privacy were growing among farmers. Unlike the other case companies, FBN avoided investing in data capturing, instead relying on importing data from other open platforms, and invested its resources in building data integration, cleaning and analysis tools. Building on these capabilities, FBN eventually offered a similar end-to-end solution as Indigo. In 2016, FBN developed its platform to include the possibility to buy and sell agricultural inputs, such as seeds, fertilizers and crop protection. Its marketplace was unique due to its connection to farmers' yield data, which enabled FBN to optimise the total profits of farms by recommending inputs with the best yield-to-price ratio. Next, FBN used the same logic to establish a grain marketplace. This time, compared to traditional grain markets, the platform optimised farmers' profits by evaluating the total cost per transaction (e.g. production, storage or transportation) against buyers' bids. At the same time, FBN introduced low-cost private-label seed products under its brand, therefore entering its own input marketplace as a supplier. In 2019, FBN announced plans to build a physical retail and logistic network to support the input marketplace and compete against traditional retailers.

CC: Founded in 2006, CC became known for its hyper-local weather monitoring, analytics and risk-management products. CC now operates one of the leading platforms in the U.S. agricultural technology ecosystem. In 2013, American agrochemical and agricultural biotechnology corporation Monsanto acquired CC to combine CC's data science capabilities with Monsanto's expertise in seeds and chemicals. CC, at the time an independent subsidiary of Monsanto, pursued vertical integration to analytics and connectivity capabilities. It announced its open platform strategy in 2016, which was followed by tens of partnerships in areas of imagery, sensors, dealer solutions, marketplaces, soil analytics, equipment connectivity, farm management and insurance. In 2018, a multinational pharmaceutical and chemical company, Bayer, acquired Monsanto, and with it CC. Under the new ownership, CC continued to develop analytical capabilities, launching new features to support Bayer's agronomic input products (e.g. Seed Advisor and disease detection).

John Deere: John Deere is an American machinery manufacturing corporation founded in 1837 and the producer of John Deere branded tractors, combine harvesters, and related equipment and services. While John Deere's products are vital for farm operations, the firm is only indirectly dependent on seed and grain markets. Nevertheless, between 2010 and 2020, John Deere developed one of the largest open platforms in the agricultural industry and has cooperated with all the other case companies. Building on its proprietary sensor, connectivity and data management solutions, John Deere launched its platform in 2012 and provided open access for third-party developers in 2013. It further vertically integrated into precision planting software and hardware by acquiring Blue River Technologies in 2017. In addition, John Deere has continuously strengthened its position in the agricultural technology ecosystem by attracting complementors to its platform from the fields of farm management, aerial imaging, data analytics and marketplaces, among others.

[1]Some documents overlap among multiple cases.

3.2. Data coding and analysis

The first step of our data analysis was to identify instances of vertical integration in the collected data. Between 2013 and 2019, the four case companies engaged in 22 ventures and operations that were identified as occurrences of vertical integration. Following the guidelines of Saldana [40], during the first coding cycle, descriptive coding was used to reflect the set of factors identified from the literature. This type of coding allowed for the observation of the temporal occurrence of different factors and evaluation of the theoretical saturation of the research data [41]. The second coding cycle relied on pattern coding, which aimed at observing relationships between the factors. Following Eisenhardt [42], emerging patterns were actively compared with extant literature. The resulting patterns were exposed to within-case analysis to analyse interdependencies and identify higher-level patterns. Finally, a cross-case analysis was conducted for the patterns with the most explanatory power.

4. Findings

The different vertical integration trajectories of the case companies and the areas they vertically integrated into are described in Figure 1. Although all firms started developing their digital platforms using a similar approach that was focused on data-based decision support for farmers, they evolved towards two different directions: the incumbents (CC and John Deere) built platforms that were dependent on third party innovators, while the start-ups (Indigo and FBN) built platforms that focused on transactions and vertically integrated into transaction-related services. From the data, three vertical integration strategies were recognised among the case companies:

1. Vertical integration from software to services to pursue systemic innovation and increase value for key platform users.
2. Vertical integration into data sources to gain proprietary control of a competitive technology and strengthen the platform's core.
3. Vertical integration between software and physical products in pursuit of a competitive advantage through product development and bundling.

Each of these is discussed separately below, with particular focus on the corresponding industry-specific characteristics.

4.1. Integration from software to services

All four case platforms were established in farm and soil analytics software. However, only the start-ups decided to vertically integrate from the software into multiple services, such as logistics, financing and grain testing. By contrast, the incumbents integrated into sensor and connectivity technology. This difference in strategy was due to the start-ups' aim to reshape the agricultural value chain, in order to attract users to their platforms by creating additional value for the platform's

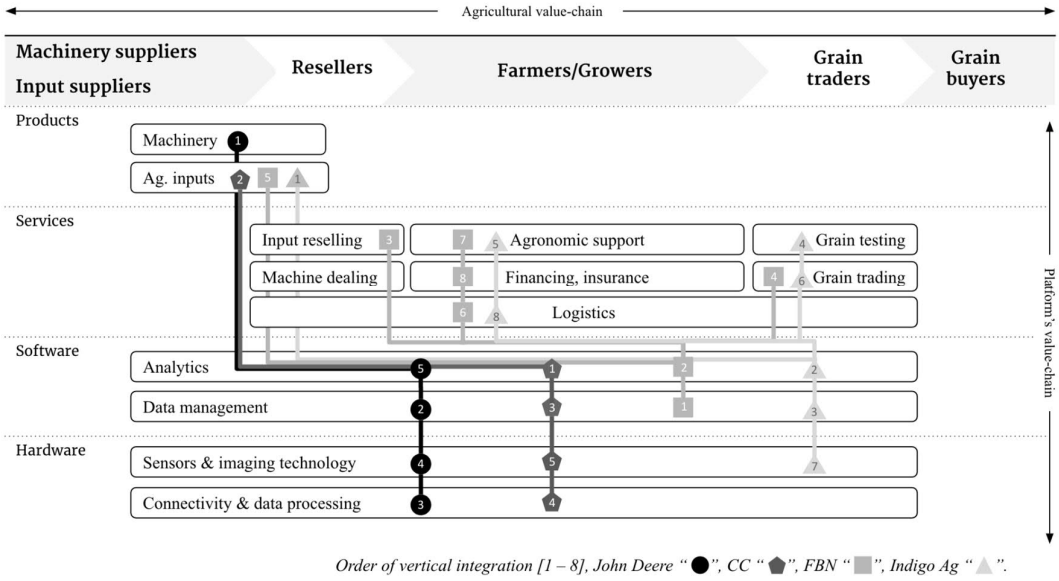

Figure 1. Vertical Integration Trajectories of the Case Companies

key users; the farmers. In particular, with this kind of vertical integration, the platform could offer farmers more control over their value chain, thus removing the requirement to manage partnerships or directly engage in vertical integration themselves.

In the traditional form of the agriculture value chain, the value was maximised in each step of the chain, which led to suboptimal overall results across the value chain. For instance, buying higher performance seeds would maximise a farm's yield, but the higher cost of these seeds would decrease the farm's total net profit. Additionally, information asymmetry is a known source of inefficiency, an example of which is the farmers' lack of access to objective seed performance information.

Making the entire value chain more efficient requires systemic innovation, including simultaneous adjustments in different activities across multiple stages of the value chain. This was explicitly noted by Indigo's CEO David Perry [43], who stated that "*We have to connect the farmer with the buyer of the crop, which reduces some costs, but which also lets the buyer get exactly what they want, and allows the farmer to connect with what that buyer wants, and perhaps produce a higher quality crop and get higher margins. And you have to take that all the way back to the input side, so that you can select inputs that allow farmers to achieve that, you got to give them microbes that allow the use of less nitrogen or fewer chemicals, and give them data science that enables them to make better choices on them.*"

For the start-ups (Indigo and FBN), these strategic intentions were achieved by vertically integrating from farm and soil software into intermediation service businesses. The start-ups aimed to act as middlemen and manage the interoperability of areas such as grain marketplace, logistics and grain testing by becoming intermediaries between existing service providers and platform users (farmers). For instance, Indigo connected logistics providers with farmers, and the interaction was facilitated by Indigo's transportation service.

By contrast, both incumbents refrained from integrating along the farmer's value chain, despite possessing the necessary technology capabilities and resources. In fact, CC benefited from the existing information and power structure by controlling a significant market share in the agricultural input market. For this reason, farmers expressed doubts about CC's potential bias in giving product or price advice. John Deere had a strong market position in machinery and related services, and was observed to focus only on competing in that part of the value chain. It appeared that incumbents were protecting the agriculture value chain's power and information structure, and faced challenges when it came to engaging in similar systemic innovation initiatives as those of start-ups.

While the benefits of systemic innovation were universal in the agricultural industry, the findings indicated that the difference between pursuing and not pursuing systemic innovation could only be explained by the background of a company, their current industry position and the way in which systemic change would influence the status quo.

Pursuing systemic innovation can be understood by viewing capabilities as drivers of vertical integration [44]. Systemic innovation requires a company to have control over capabilities in different parts of a value chain. By reconfiguring and linking those capabilities, the company can innovate across the system or the value chain. In the digital platform literature, it is often assumed that this type of control and reconfiguration occurs through ecosystems. Each company specialises in a single activity in an ecosystem while aligning to produce a uniform system [18]. Although certain aspects of this have been observed in the agriculture sector, the case companies discussed herein used vertical integration to achieve the same outcome while relying on hierarchical control. In other words, vertical integration was used as an alternative for ecosystem development.

The benefits obtained could be explained by the transaction cost theory, since coordinating and managing ecosystems could have created operational and opportunity costs for the actors involved [45]. In a sector like agriculture, which has established production structures and where actors are likely to be against changing the status quo, the cost of aligning the ecosystem to produce systemic innovations may quickly and markedly rise.

4.2. Integration from software to sensor, connectivity and imaging hardware

All case companies sought to enhance their access to data or gain a competitive advantage by controlling proprietary data sources. What happened in practice was that companies vertically integrated towards sensor, connectivity and imaging technologies to control data sources. For example, Indigo acquired a satellite imaging start-up, CC invented a connectivity hub to collect planting data, and John Deere acquired plant imaging start-up Blue River.

The aim of these vertical integrations towards data sources was to ensure the supply of data, while having proprietary control of a capability that could potentially improve the performance of the company's other activities. The importance of synergies was rather obvious, as demonstrated by comments such as *"the new data from TellusLabs will be relevant across business units, including helping Indigo to market its microbial products based on a grower's yield potential*

and unique land characteristics" [46] and *"[Blue River's technology] will help make all John Deere machines smart and not just in ag [agriculture]"* [47]. While agricultural technology was a nascent market, where particular technologies were not yet widely available through market exchange, the existence of such synergies provided a solid motivation to internalise and protect an activity from competitors [4].

Vertically integrating into data sources can also be understood from the perspective of the platform's position in the market and their market power [4, 27]. Standard setting and interoperability played an essential role in technology-related vertical integration. In this area, incumbents had control over the industry's key standard-setting initiatives. As a result, these standards could be used to influence the market and competitive dynamics in a way that was favourable for the incumbent's vertical scope. John Deere's director, John Teeple, described this in the following manner: *"[We're] always looking to improve interoperability, but when it comes to what we can control, we certainly focus on our vertical integration and [...] maximizing our sources of competitive advantage [...] Where we know that there are others in the industry that we know are better equipped. [...] That's where we look to understand how we can establish international standards"* [48].

For example, increased standardisation of precision agriculture data (intra-field crop variability information) resulted in all case companies utilizing partnerships to access new data sources and share data. FBN took the most advantage of increased standardization, by relying entirely on data exchange partnerships and avoiding vertical integration into sensors and connectivity hardware. The findings indicated that, as the efficiency of partnering or using market-based exchange increased, standardization reduced motivation for controlling proprietary data through vertical integration. Whether these capabilities and partnerships are available in a specific industry is likely to be dependent on the industry's level of maturity, assuming that the number of feasible partnerships increases over time [49].

Vertical integration into data sources was found to strengthen a platform's core capabilities, consequently improving the quality and features of its existing services. Furthermore, consistent with the findings of Porter [4], it allowed platforms to differentiate their offering through unique proprietary solutions, such as artificial intelligence-based precision planting. However, the use of market power to influence standard-setting highlighted the different options available for start-ups and incumbents.

4.3. Integration between software and physical assets

In the agriculture value chain, physical assets comprise an exponentially larger market than that of information-based services. Consequently, all case companies eventually integrated physical assets and digital artefacts, such as software products. For example, Indigo, FBN and CC expanded from soil analytics to agronomic inputs, such as seeds, fertilizer and crop protection, and John Deere from machinery to farm management software. Two types of drivers for this expansion were observed.

First, both start-ups mentioned gaining a competitive advantage in product development by creating a feedback loop between farmers and research and development (R&D), enabling more rapid and accurate physical product development. FBN stated that *"[Our] R&D is linked with the grower, and shows how this product really works on real fields. And that's driving our ability to deliver better products"* [50]. Similarly, Indigo stated that *"While Indigo's products are physical (microbial products and coated seeds), the core of the company has always been our computational biology platform [...] As we and our academic collaborators generate data from lab experiments, greenhouse experiments, and field trials, we use these results to refine the algorithms. Continuing to gather commercial data from customers who are using our products under a wide range of conditions is just a natural extension of our approach to innovation"* [51].

Both examples demonstrate the intention to compete with increased quality achieved by gaining access to information flows between the different stages of the value chain and leveraging platform users as a testing group for the product. However, utilizing this information flow in agriculture remains challenging, due to the high variability between different geographical areas and the long delays between planting the seed and receiving the results on crops. Therefore, from the perspective of capabilities as drivers of vertical integration [23, 24], the size of the established user base becomes a critical capability, since an increasing number of users enables the platform to gain enough data for accurate R&D. Indeed, the start-ups' success to gain a share on a very competitive seed market controlled by incumbents, such as CC, demonstrates the strategic significance of using vertical integration to establish missing feedback loops between platform users and physical products.

Second, all case companies noted that their software would further increase the efficiency of the physical products, and three out of four case companies provided their proprietary products and software services as a bundle. At the same time, existing user

bases can help solve some of the inherent challenges of digital platforms, such as attracting users from different user groups onto the platform, particularly favouring the established user bases of the incumbent companies.

Vertical integration between software and physical products enables companies to pursue a competitive advantage through product development. This may get confused with horizontal integration, where leveraging shared development capabilities is common. However, the integration of software and physical products creates information feedback loops, such as product performance data obtained from platform users, enabling the creation of whole new data-driven R&D processes and capabilities and going beyond simply maximising resource usage. In that sense, the integration of software and physical products is closely linked to a company's core value chains, and having control over both becomes a source of competitive advantage [25] in areas such as product development [18]. Furthermore, accessing information flows allows companies to fend off challenges that emerge from existing information asymmetries in the industry [36].

5. Discussion

Two emerging factors characterise the vertical integration of digital platforms. First, the vertical integration of platforms can focus on the users' value chains, and second, data is a key driver of vertical integration.

5.1. Vertical integration of the users' value chains

In the analysed cases, vertical integration of digital platforms in the agricultural industry appeared to often occur along the value chain of its key users, such as farmers. In other words, instead of vertically integrating solely into different parts of the platform's value chain, such as backend hardware, service delivery or support functions, the studied platforms vertically integrated into various stages of the farmers' value chain as well. For instance, case platforms expanded to areas such as agronomic inputs, logistics and marketplaces, all of which formed an integral part of the farmer's value chain. Control over these activities enabled platforms to implement systemic innovations by aligning activities across the different stages of that value chain.

Two industry-level factors facilitated vertical integration of this type. First, while the agricultural industry had so far been characterised by the relatively powerful companies occupying each of the different stages of the value chain, there had been fewer actors looking for systemic innovation to fix inefficiencies across the entire value chain. This industry setting enabled start-ups to vertically integrate into the different stages of the farmer's value chain and control those stages, while incumbents faced an opportunity cost of changing the current structure.

Second, the relatively clear and focused value chains of the industry required more coordination between activities. In agriculture, services and products used by farmers are naturally unique compliments, since they depend on each other's inputs and outputs, and the range of services demanded is narrower than that in consumer-oriented platforms, such as Apple's App Store. In this type of tightly coupled system, innovation often requires changes across multiple activities [29]. Vertical integration appears to have been used as an alternative for ecosystem creation, as it has enabled companies to reap similar benefits to those linked to ecosystems [18] while avoiding certain inconveniences, such as transaction costs [45].

From a platform's perspective, this type of approach to vertical integration required the internalization of the farmers' role in the industry and the application of vertical integration along the farmers' value chain. Traditionally, the focus of vertical integration research has been on the company's supply chain, such as on determining whether a manufacturing company should also control the providers of its components. However, in the study of vertical integration of digital platforms, the focus should also be on the value chains of the platform's key users and control of the different stages of that chain.

5.2. Data as a driver of vertical integration

Another characteristic of the vertical integration activities of digital platforms was the role of data and data flows across the value chain. By vertically integrating different stages of the farmers' value chain, data obtained from one stage offered synergies across other stages. As indicated in the literature, it enabled the platforms to improve their efficiency and quality [44].

The size and activity of a platform's installed base are of key importance, since they translate into more, as well as more accurate, information, eventually leading to competitive advantages. For example, the scale and frequency of user-sourced information enabled start-ups to develop physical products, challenging incumbents that relied on limited laboratory-based data collection. In other platform markets, user-based information has provided similar opportunities and encouraged platforms to enter adjacent markets, indicating that vertical integration possibilities increase as the availability of data increases.

Thus, some of the case companies vertically integrated into technologies enabling better data capture

and flow. However, other factors, such as standards, can diminish the need for such vertical integration by lowering transaction costs [32]. Increasing standardization enabled platforms to access data assets through partnerships, instead of owning the data source. However, incumbent platforms had more control over standard-setting organisations, which enabled them to use standard-setting as a strategic tool.

Overall, data within and across industries provide new opportunities for vertical integration in areas such as sensors, connectivity, data analytics and provision of data-driven services. For instance, obtaining data from physical assets drives integration from software to physical products and highlights the role of sensors and other data sources in the equation.

6. Conclusion

The drivers of vertical integration presented in the extant literature on traditional organizations also largely apply to digital platforms. The agricultural value chain context revealed integration strategies 1) towards services and user value chains, 2) towards data sources and platform value chains, and 3) between boundaries of physical and digital products. The present findings demonstrated how all three theoretical perspectives – efficiency, capabilities and market power – were associated with these strategies.

Two differences were observed between our findings and those of extant literature. First, as platforms focus on managing transactions and contributions from third-party actors instead of on a clearly defined value chain, vertical integration of digital platforms needs to be evaluated from the perspective of the value chains of the key users, not exclusively that of the platform itself. Second, due to the digital nature of these platforms, data generated by a platform's users play a crucial role in the function and expansion of the platform. Therefore, despite the many differences between different industries, focusing on these two factors can help understand the paradoxical nature of vertical integration activities in digital platforms.

The agricultural industry has certain specific characteristics, such as the relative clarity of value chains or established power structures, which may exist to a lesser extent in other industries. More research is needed, for instance, to better understand why and how digital platforms use vertical integration strategies in other industries. We hope that the present study provides a starting point for such future research.

6. References

[1] Ansoff, H.I., "Strategies for diversification", Harvard business review 35(5), 1957, pp. 113–124.

[2] Peyrefitte, J., P.A. Golden, and J. Brice, "Vertical integration and economic performance: a managerial capability framework", Management Decision, 2002.

[3] Williamson, O.E., "The Vertical Integration of Production: Market Failure Considerations", The American Economic Review 61(2), 1971, pp. 112–123.

[4] Porter, M.E., Competitive Strategy: Techniques for Analyzing Industries and Competitors, Free Press, New York, USA, 2004.

[5] Guan, W., and J. Rehme, "Vertical integration in supply chains: driving forces and consequences for a manufacturer's downstream integration", Supply Chain Management: An International Journal 17(2), 2012, pp. 187–201.

[6] Alstyne, M.W.V., G.G. Parker, and S.P. Choudary, "Pipelines, Platforms, and the New Rules of Strategy", Harvard Business Review, 2016. https://hbr.org/2016/04/pipelines-platforms-and-the-new-rules-of-strategy

[7] Parker, G., M. Van Alstyne, and X. Jiang, "Platform Ecosystems: How Developers Invert the Firm", MIS Quarterly 41(1), 2017, pp. 255–266.

[8] Eaton, B., S. Elaluf-Calderwood, C. Sørensen, and Y. Yoo, "Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System", MIS Quarterly 39(1), 2015, pp. 217–243.

[9] Ghazawneh, A., and O. Henfridsson, "Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model", Information Systems Journal 23(2), 2013, pp. 173–192.

[10] Boudreau, K., "Open Platform Strategies and Innovation: Granting Access vs. Devolving Control", Management Science 56(10), 2010, pp. 1849–1872.

[11] Zhu, F., and Q. Liu, "Competing with complementors: An empirical look at Amazon.com", Strategic Management Journal 39(10), 2018, pp. 2618–2642.

[12] Tiwana, A., Platform Ecosystems: Aligning Architecture, Governance, and Strategy, Newnes, 2014.

[13] Gawer, A., "Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces", Long Range Planning, 2020, pp. 102045.

[14] Day, S., "Agtech Landscape 2019: Innovation on the farm & in the 'messy middle'", AgFunderNews, 2019. https://agfundernews.com/2019-06-04-agtech-landscape-2019-1600-startups.html

[15] Estes, V., "How Big Data is Disrupting Agriculture from Biological Discovery to Farming Practices", AgFunderNews, 2016. https://agfundernews.com/how-big-data-is-disrupting-agriculture-from-biological-discovery-to-farming-practices5973.html

[16] Harrigan, K.R., "A Framework for Looking at Vertical Integration", Journal of Business Strategy 3, 1983, pp. 30–37.

[17] Zhao, Y., S. von Delft, A. Morgan-Thomas, and T. Buck, "The evolution of platform business models: Exploring competitive battles in the world of platforms", Long Range Planning 53(4), 2020, pp. 101892.

[18] Jacobides, M., C. Cennamo, and A. Gawer, "Towards a Theory of Ecosystems", Strategic Management Journal 39(8), 2018, pp. 2255–2276.

[19] Bresnahan, T.F., and J.D. Levin, Vertical Integration and Market Structure, National Bureau of Economic Research, Inc, 2012.
[20] Helfat, C.E., and M.A. Campo-Rembado, "Integrative Capabilities, Vertical Integration, and Innovation Over Successive Technology Lifecycles", Organization Science 27(2), 2016, pp. 249–264.
[21] Eisenmann, T., G. Parker, and M.V. Alstyne, Opening Platforms: How, When and Why?, Social Science Research Network, Rochester, NY, 2008.
[22] Blondel, F., and S. Edouard, "Entrance into a platform-dominated market: Virtue of an open strategy on the numerical computation market", Canadian Journal of Administrative Sciences / Revue Canadienne des Sciences de l'Administration 32(3), 2015, pp. 177–188.
[23] Amit, R., and P.J.H. Schoemaker, "Strategic assets and organizational rent", Strategic Management Journal 14(1), 1993, pp. 33–46.
[24] Argyres, N., "Evidence on the role of firm capabilities in vertical integration decisions", Strategic management journal 17(2), 1996, pp. 129–150.
[25] Díez-Vial, I., "Explaining Vertical Integration Strategies: Market Power, Transactional Attributes and Capabilities", Journal of Management Studies 44(6), 2007, pp. 1017–1040.
[26] Li, H.-L., and M.-J. Tang, "Vertical integration and innovative performance: The effects of external knowledge sourcing modes", Technovation 30(7), 2010, pp. 401–410.
[27] Wit, B. de, and R. Meyer, Strategy: Process, Content, Context, Cengage Learning, 2010.
[28] Hill, C.W.L., and G.R. Jones, "Strategy and Technology", In C.W.L. Hill, G.R. Jones and M.A. Schilling, eds., Strategic Management: Theory: An Integrated Approach. Cengage Learning, 2014.
[29] Ulrich, K., "The Role of Product Architecture in the Manufacturing Firm", Research Policy 24(3), 1995, pp. 419–440.
[30] Funk, J.L., and J. Luo, "Open standards, vertical disintegration and entrepreneurial opportunities: How vertically-specialized firms entered the U.S. semiconductor industry", Technovation 45–46, 2015, pp. 52–62.
[31] Baldwin, C.Y., and C.J. Woodard, "The Architecture of Platforms: A Unified View", In A. Gawer, ed., Platforms, Markets and Innovation. Edward Elgar Publishing, Cheltenham, UK, 2009.
[32] Helfat, C.E., "Vertical firm structure and industry evolution", Industrial and Corporate Change 24(4), 2015, pp. 803–818.
[33] Gawer, A., and M.A. Cusumano, "Industry Platforms and Ecosystem Innovation", Journal of Product Innovation Management 31(3), 2014, pp. 417–433.
[34] Johnson, G., R. Whittington, K. Scholes, D. Angwin, and P. Regnér, Exploring strategy, Financial Times Prentice Hall, 2011.
[35] Afuah, A., "Are network effects really all about size? The role of structure and conduct", Strategic Management Journal 34(3), 2013, pp. 257–273.
[36] Akerlof, G.A., "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism", The Quarterly Journal of Economics 84(3), 1970, pp. 488–500.
[37] Hennessy, D.A., "Information Asymmetry as a Reason for Food Industry Vertical Integration", American Journal of Agricultural Economics 78(4), 1996, pp. 1034–1043.
[38] Lin, M., Y. Liu, and S. Viswanathan, "Effectiveness of Reputation in Contracting for Customized Production: Evidence from Online Labor Markets", Management Science 64(1), 2018, pp. 345–359.
[39] Constantiou, I., B. Eaton, and V.K. Tuunainen, "The Evolution of a Sharing Platform into a Sustainable Business", Proceedings of the 49th Hawaii International Conference on System Sciences (HICSS 2016), 2016, pp. 1297–1306.
[40] Saldaña, J., The coding manual for qualitative researchers, Sage Publications Ltd, Thousand Oaks, CA, 2009.
[41] Pettigrew, A.M., "Longitudinal Field Research on Change: Theory and Practice", Organization Science 1(3), 1990, pp. 267–292.
[42] Eisenhardt, K.M., "Building Theories from Case Study Research", The Academy of Management Review 14(4), 1989, pp. 532–550.
[43] Indigo Ag, Indigo CEO David Perry: On Innovating In Agriculture, 2018.
[44] Argyres, N.S., and T.R. Zenger, "Capabilities, Transaction Costs, and Firm Boundaries", Organization Science 23(6), 2012, pp. 1643–1657.
[45] Jacobides, M.G., and S.G. Winter, "The Co-Evolution of Capabilities and Transaction Costs: Explaining the Institutional Structure of Production", Strategic Management Journal 26(5), 2005, pp. 395–413.
[46] Burwood-Taylor, L., "Indigo Acquires Satellite Imagery Startup TellusLabs for 'Living Map of World's Food Supply'", AgFunderNews, 2018. https://agfundernews.com/breaking-indigo-acquires-satellite-imagery-startup-telluslabs-for-living-map-of-worlds-food-supply.html
[47] Burwood-Taylor, L., "Blue River Was 'Clear Leader' in John Deere's Search for a Robotics & AI Acquisition", AgFunderNews, 2017. https://agfundernews.com/blue-river-clear-leader-john-deeres-search-robotics-acquisition.html
[48] Gold, J., "IoT innovation at John Deere: A Skunk Works with tractors | Network World", 2017. https://www.networkworld.com/article/3198744/a-skunk-works-with-tractors-inside-john-deere-s-high-tech-iot-innovation-unit.html
[49] Christensen, C.M., M. Verlinden, and G. Westerman, "Disruption, disintegration and the dissipation of differentiability", Industrial and Corporate Change 11(5), 2002, pp. 955–993.
[50] Farmers Business Network, The Performance Data You've Been Waiting For: F2F Genetics Network Yield Data + ROI Analysis Webinar, 2020.
[51] Perry, D., "Indigo Innovation: A Model of Continuous Improvement", 2016. https://www.indigoag.com/blog/indigo-innovation-a-model-of-continuous-improvement