

Digital platforms in the agricultural sector: Dynamics of oligopolistic platformisation

Big Data & Society
October–December 1–16
© The Author(s) 2024
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/20539517241306365
journals.sagepub.com/home/bds



Monja Sauvagerd¹ , Maximilian Mayer²
and Monika Hartmann¹

Abstract

This paper introduces the concept of ‘oligopolistic platformisation’ to capture the specific dynamics of collaboration and competition between multinational upstream agribusinesses and Big Tech companies in the agricultural (ag) sector. We examine this phenomenon through the lens of Van Dijck et al.’s platform mechanisms: datafication, selection and commodification. Multinational agribusinesses operate sectoral ag platforms that analyse spatial, weather and agronomic data to optimise farming operations, whilst Big Tech companies provide the digital infrastructure, including cloud computing, data analytics and artificial intelligence. We explore how these pre-existing oligopolistic market structures influence the process and outcomes of platformisation in the ag sector. Using expert interviews, field observations, economic relationship mapping and an extensive literature review, we investigate relationships amongst multinational agribusinesses and between agribusinesses and Big Tech companies. Our findings reveal that Big Tech and multinational agribusinesses are collaboratively establishing digital platforms as the core organisational form of digital agriculture, aiming to consolidate most services. This collaboration blurs the lines between traditionally distinct industries, fostering overlapping ecosystems and mutually beneficial economic relationships in an already highly concentrated market. This dynamic has the potential to reinforce the market position of established companies, increase farmers’ dependency on agribusinesses and contribute to fragmented and siloed data systems.

Keywords

Platformisation, digital agriculture, digital platforms, artificial intelligence, Big Tech, agribusiness

Introduction

Digital platforms and their ecosystems have become the dominant organisational form in the digital economy, reorganising markets and redefining value creation, industry coordination and innovation (Gawer, 2021; Kenney et al., 2019). Referred to as the ‘platform economy’ (Kenney and Zysman, 2016) or ‘platform capitalism’ (Smicek, 2017a), these platforms, powered by big data and artificial intelligence (AI), form the core of new business models. In their analysis of ‘platformisation’ across sectors like news, urban transport, health and education, Van Dijck et al. (2018) show how platforms often disrupt existing markets and lead to the rise of (new) dominant players.

In contrast, the agricultural (ag) sector presents a diverging case. Rather than new entrants disrupting the market, digital platforms in agriculture have integrated into pre-existing oligopolistic market structures dominated by a few multinational agribusinesses and Big Tech companies. This paper introduces the concept of ‘oligopolistic platformisation’ to describe the specific dynamics of collaboration

and competition amongst and between two of the most profitable and highly concentrated global industries: multinational upstream agribusinesses¹ and Big Tech companies.² Unlike platformisation in other industries, where new entrants often disrupt existing structures, oligopolistic platformisation in the ag sector reinforces market concentration amongst existing players. By employing digital platforms, agribusinesses and Big Tech companies aim to further consolidate their influence over ag inputs, data and

¹Institute for Food and Resource Economics, University of Bonn, Bonn, Germany

²Center for Advanced Security, Strategic and Integration Studies, University of Bonn, Bonn, Germany

Corresponding author:

Monja Sauvagerd, Department of Agricultural and Food Market Research, Institute for Food and Resource Economics, University of Bonn, Nußallee 21 (Haus 2), 53115 Bonn, Germany.
Email: monja.sauvagerd@ilr.uni-bonn.de



services, which can significantly impact industry coordination, innovation and overall value creation.

This paper qualitatively explores how these oligopolistic market structures shape the process and outcomes of platformisation in the ag sector, particularly in commodity cropland farming systems.³ We show that the integration of digital platforms into this industry has resulted in the formation of an Ag-Big Tech Complex, where agribusinesses operate sectoral platforms focusing on specific niches, whilst Big Tech provides the underlying infrastructural platforms for data analytics, AI and cloud computing.⁴ Multinational agribusinesses, spanning ag machinery, agrochemicals, seeds and biotechnology, offer sectoral platforms to farmers for decision-making support. These platforms can create digital twins of farms (Pylianidis et al., 2021), integrating real-time field-specific data for decision-making and optimisation of farming operations. They combine datasets with factors such as space, climate, weather, machine and agronomic⁵ data into forecasting models. Notable sectoral ag platforms include Bayer's Climate Field View, BASF's xarvio, John Deere Operations Center, CLAAS connect and its 365 FarmNet, Yara's YaraPlus and Syngenta's Cropwise. Conversely, Big Tech companies like Amazon, Microsoft and Google lease their infrastructural platforms to these agribusinesses, enabling them to utilise advanced data analytics and cloud computing.

Research on digital technologies in agriculture highlights their potential to address climate change, food insecurity and environmental degradation. By precisely measuring field conditions and adapting the strategies accordingly, digital ag platforms promise to produce more food on less land with fewer inputs and a smaller ecological footprint, improving soil health, conserving water and enhancing resilience to extreme weather events (Finger et al., 2019; Gebbers and Adamchuk, 2010; McNunn et al., 2020; Weersink et al., 2018). However, scholars emphasise concerns about how digital technologies in the ag sector may exacerbate power asymmetries between farmers and multinational agribusinesses (Bronson, 2019; Bronson and Knezevic, 2016; Clapp and Ruder, 2020; Rotz, Duncan, et al., 2019; Verdonk, 2019). Issues regarding ag data ownership, privacy and security have also been raised (Atik, 2022; Sykuta, 2016; Wolfert et al., 2017). Additionally, there are potential adverse effects on ag labour practices and social relationships across global food production systems, including increased inequalities between smallholder farmers and agro-industrial producers (Drach et al., 2017; Klerkx and Rose, 2020; Prause et al., 2021; Tsouvalis et al., 2000).

Whilst contributions from Maschewski and Nosthoff (2022), Bronson and Sengers (2022) and Hackfort et al. (2024) provide valuable insights into the role of Big Tech and agribusinesses in transforming ag data into value, their focus is primarily on data strategies, technological control and socio-ecological implications. However, a

significant research gap remains in understanding the economic relationships and platform business models employed by these industries to create and capture value within digital agriculture. This paper addresses this gap by investigating the cross-sectoral collaborations and competitive dynamics between and amongst multinational agribusinesses and Big Tech companies, offering a deeper examination of the potential of platformisation in reshaping market power and control over ag data and services.

Our paper makes several contributions to the literature on digital platforms within the ag sector. First, it is the first paper that applies Van Dijck et al.'s (2018) concept of platformisation to the ag sector. Second, we introduce the concept of 'oligopolistic platformisation', presenting a theoretical framework to elucidate how digital platforms tend to reinforce rather than disrupt existing oligopolistic structures, thereby consolidating market power amongst dominant players. Third, our paper maps the relationships between Big Tech firms and agribusinesses, as well as amongst agribusinesses themselves, uncovering a concentrated power dynamic that often disadvantages smaller start-ups. These mappings illustrate the coexistence of collaboration and competition, where selective data sharing and technological integration enable incumbent firms to protect their market positions, despite some degree of cooperation. Finally, the paper provides critical policy insights for addressing power asymmetries and data fragmentation in the sector.

The paper is structured as follows. We begin by developing the theoretical framework of 'oligopolistic platformisation', integrating platform studies with economic theory. The paper then outlines our qualitative research design, based on expert interviews, economic relationship mapping, field observations and a semi-structured literature review. Next, we provide an overview of macro-structural trends in ag industrialisation. The analysis applies Van Dijck et al.'s (2018) platform mechanisms of datafication, selection and commodification, demonstrating how oligopolistic platformisation unfolds in the ag sector, with agribusinesses and Big Tech companies using digital platforms to expand their market position, shaping industry coordination, collaboration, competition and innovation. Finally, we discuss the potential implications of these dynamics for farmers, policymakers and stakeholders in the ag sector.

Theory and analytical framework

Digital platforms have emerged as powerful drivers of industry transformation, with newcomers disrupting and reshaping sectors, compelling established players to adapt or lose market share (Ciligit, 2020). These platforms are particularly well-adapted to the novel ways of creating and capturing value given the new technological conditions of the digital age (Gawer, 2021), reshaping industrial architectures from products to services and solutions (Gawer,

2009). As key drivers for restructuring the global economy, they have gathered enormous influence, potentially giving their owners more power than early industrialists (Kenney, Zysman et al., 2021). Central to their dominance is the potential for winner-takes-all dynamics (Schilling, 2002), where platforms leverage network effects to exponentially increase their value as their user base grows, leading to market concentration and creating high barriers to entry for competitors (Baldwin and Woodard, 2009; Boudreau and Jeppesen, 2015; Rochet and Tirole, 2002; Tirole, 2023).

A key feature of digital platforms is their reliance on data as a foundational resource. Training data enhances algorithms, personalises content and generates data-driven services, creating ‘feedback loops’ that further solidify a platform’s market dominance (Bajari et al., 2019; Srnicek, 2017a). Early entrants often gain a first-mover advantage, benefitting from network effects and creating high barriers for competitors (Katz and Shapiro, 1994; Shapiro and Varian, 1999). Although some platform companies, like Uber, have historically reported losses (Cusumano et al., 2019), investors continue to invest due to the anticipation of a ‘winner take all or most’ scenario (Cusumano, 2022).

Digital platforms typically function as two-sided markets, connecting diverse customer groups and facilitating extensive goods and services, often relying on an ecosystem of autonomous agents to co-create value (Boudreau and Hagiu, 2008; Hein et al., 2020; Rietveld and Schilling, 2021). Their success is driven by economies of scale, which enable cost reduction and the reinforcement of a platform’s dominant position (Baldwin and Woodard, 2009; Boudreau and Jeppesen, 2015; Rochet and Tirole, 2002; Tirole, 2023). As a result, many digital platforms evolve into concentrated markets, characterised by limited competition and dominant players (Scott Morton et al., 2023).

Drawing on these insights and *The Platform Society* (Van Dijck et al., 2018), we analyse how platformisation reshapes economic relationships and organisational forms in the ag sector along three central mechanisms: datafication, selection and commodification. Datafication captures and circulates data on platforms, including previously unquantifiable aspects like behavioural metadata (Van Dijck et al., 2018: 33), allowing platforms to function as ecosystems through data exchange. Big Tech companies, positioned at the centre of this ecosystem, control the circulation of data to and from other platforms via their infrastructural platforms. Selection curates relevant content and services through personalisation and moderation practices (Van Dijck et al., 2018: 40), using data-driven algorithms based on user behaviour. Finally, commodification transforms user data and interactions into tradable commodities and marketable products (Van Dijck et al., 2018: 37). The latter is closely connected to datafication and selection as commodification relies on the extensive data collection

and algorithmic curation to combine data, user behaviour and preferences into commodities and services for commercial purposes.

The ag sector presents a unique case where pre-existing oligopolistic structures, rather than disruptive new entrants, dominate platformisation. Multinational agribusinesses such as Bayer, John Deere, BASF and Syngenta have long played a significant role in ag markets for seeds, agrochemicals and machinery. Along with Big Tech companies like Google, Amazon and Microsoft, these incumbents have extended their dominance into digital agriculture, a process we term ‘oligopolistic platformisation’. Oligopolistic platformisation differs from platformisation described by (Van Dijck et al. (2018) in four key ways as summarised in Table 1.

Methodology

Our study follows a qualitative triangulation design which is particularly suitable because the ag sector’s oligopolistic market structure differs from other sectors where platformisation is driven by disruptive new entrants, requiring a flexible and iterative method to capture its unique dynamics. The qualitative methods employed include a semi-structured literature review, expert interviews and field observations, as well as information gathered from press releases and registration on various sectoral ag platforms.⁶ Guided by an abductive research design, which involves developing new theoretical insights through iterative refinement based on empirical data, we develop our concept of ‘oligopolistic platformisation’.

Our literature review drew on the academic databases Scopus, Web of Science and Google Scholar, focusing on peer-reviewed articles, industry reports and white papers. Search terms included ‘digital agriculture’, ‘platform economics’, ‘platformisation’, ‘precision farming’, ‘agtech’ and ‘political economy’. Whilst we did not keep an exact count of all items retrieved, approximately 300 publications were reviewed after screening titles and abstracts. These initial results were further refined using Van Dijck et al.’s (2018) platform mechanisms – datafication, selection and commodification – and literature on market structures associated with platform economics. This process yielded a focused set of 150 sources that informed our theoretical and conceptual framework.

Additionally, we conducted twelve expert interviews from 2022 to 2024 with multinational upstream agribusinesses, including Bayer, BASF, CLAAS and John Deere; from Big Tech companies, including Microsoft, Google and Amazon Web Services (AWS); and key stakeholders like start-ups, farmers’ associations, policymakers and research institutions. Interviewees were selected through strategic LinkedIn searches, university networks and industry and networking events, employing a mix of purposive and snowball sampling methods (Morgan, 2008). Based

Table 1. Comparison of platformisation by Van Dijck et al. (2018) and oligopolistic platformisation.

Platform mechanism	Platformisation according to Van Dijck et al. (2018)	Oligopolistic platformisation	
		Sectoral platforms (agribusinesses)	Infrastructural platforms (Big Tech)
Structural and organisational changes	New entrants (e.g. Uber) disrupt traditional industries (e.g. urban transportation) and dominate through winner-takes-all dynamics. Platforms become central organisational structures, often leading to market consolidation around a single dominant player.	Incumbent agribusinesses extend their oligopolistic positions by integrating digital platforms. This results in multiple platform ecosystems, each controlled by different incumbents, rather than a single dominant platform, leading to fragmentation.	Big Tech gains relevance in the ag sector by providing essential infrastructure (e.g. cloud computing, AI) but to date, it has not directly disrupted agribusiness incumbents. Their platforms serve as back-end solutions, supporting data analytics and algorithmic processes that reinforce the oligopolistic nature of the sector.
Datafication	Data from user interactions and processes is captured by a single sectoral platform, creating closed data ecosystems.	Agribusinesses collect farm-specific data to optimise input usage and farming operations. Data is partially shared across sectoral platforms, but fragmentation persists as incumbent agribusinesses maintain control over their respective ecosystems, leading to siloed data systems (Figure 1).	Big Tech companies store and process vast amounts of ag data from various sources. They provide advanced analytics and data storage solutions to sectoral platforms, acting as the central hubs for data integration across the ag sector.
Selection	Platforms use algorithms to replace expert-based selection with user-driven and data-driven selection, optimising content and services delivered based on user preferences.	Agribusinesses use algorithmic selection to optimise content and service recommendations, often prioritising their products and services, which can create information asymmetries. Additionally, incompatible data formats lead to vendor lock-ins, consolidating market power and limiting choices for farmers.	Big Tech supplies the algorithms, machine learning models and analytics tools used by sectoral platforms to enhance predictive models and optimise farming decisions. Their technology underpins the agribusinesses' control over recommendations and content delivery.
Commodification	Solutions (products, services and product-service combinations) based on user data and data analytics are commodified generating revenue.	Agribusinesses commodify user data by integrating it with traditional products (e.g. seeds, agrochemicals, machinery) to create digital solution packages that reinforce core business activities to strengthen market dominance. These packages include crop management services, multisided markets, product-as-a-service models and carbon monitoring tools. Most sectoral platforms remain in the investment phase, cross-funded by agribusinesses' core businesses to stay competitive until profitability is reached.	Big Tech commodifies ag data indirectly by offering infrastructure, essential cloud computing and data analytics services to agribusinesses, startups and public institutions. Platforms (e.g. AWS, Microsoft Azure, Google Cloud) scale digital agriculture infrastructure and benefit from network effects. Big Tech provides the backbone for data processing, AI development and predictive analytics but does not directly control or access the content of the agribusiness data.

Note. ag, agricultural; AI, artificial intelligence; AWS, Amazon Web Services.

on insights from the expert interviews additional literature was considered in the analysis.

The semi-structured interview format allowed for discussion of pre-defined factors adapted to each interview partner whilst permitting the interviewees to raise or expand upon aspects they deemed particularly relevant (Clifford et al., 2010). During the interviews, participants highlighted additional economic themes not captured by Van Dijck et al.'s (2018) framework, such as simultaneous

competition and collaboration dynamics and lock-in effects. This prompted us to expand our theoretical lens, incorporating these economic factors. The evolving codebook and qualitative content analysis (Mayring, 2021) ensured that our analysis remained grounded in empirical realities. Theoretical saturation (Glaser and Strauss, 1980) was achieved, with recurring themes and stakeholder inputs indicating data sufficiency. Interviewees reviewed and commented on their (paraphrased) statements, and

consent was obtained before publication, ensuring accuracy and reliability. Only statements that are clearly indicated to originate from an interview partner should be attributed to that person.

Complementing the interviews, we conducted ten systematic field observations (McCall, 1984) between 2022 and 2024 at network events held by various industry stakeholders, international organisations and leading universities in digital agriculture, including both in-person and online events (see supplementary documents). Additionally, we undertook field trips to farms to contextualise and validate findings from expert interviews.

To map the inter-firm relationships amongst leading agribusinesses and between agribusinesses and Big Tech companies, we created two network visualisations based on press releases, platform registrations and company reports. By enrolling in various sectoral ag platforms and systematically documenting data-sharing capabilities from the perspective of the farmer, we comprehensively mapped partnerships amongst agribusinesses (Figure 1). Collaborations involving Big Tech companies, agribusinesses, start-ups and public institutions (Figure 2) were further mapped using publicly available reports, press releases and farm newspapers. The network diagrams were generated using the data visualisation software Flourish.

Platformisation of the ag sector: an emerging ag-Big Tech complex

The platformisation of the ag sector builds on long-term trends in ag industrialisation, particularly in the Global North and BRICS countries, alongside the liberalisation, globalisation and concentration of ag markets (Clapp et al., 2018; Robinson, 2018; Van der Ploeg, 2010). Strategic mergers, such as DuPont and Dow Chemical, ChemChina's acquisition of Syngenta and Bayer's takeover of Monsanto, have created oligopolistic market structures blurring boundaries between seeds, agrochemicals, biotechnology and digital agriculture (Strömberg and Howard, 2023).

Monsanto's acquisition of The Climate Corporation, a digital ag company that utilises AI for weather, soil and field data analysis and its later absorption into Bayer's operations,⁷ exemplifies how traditional agribusinesses integrate digital technologies whilst maintaining sectoral control. Similarly, John Deere's (2021) acquisition of Bear Flag Robotics was aimed at advancing autonomous farming technologies (John Deere, 2021). However, rather than disrupting the industry, this acquisition further entrenched John Deere's dominance in the ag sector. Both companies also strategically use corporate venture capital to invest in external start-ups, gaining innovation advantages whilst driving new technologies within their operations (Bayer AG, 2023; John Deere, 2024). These

investments align with oligopolistic platformisation, whereby incumbents secure early-mover advantages through vertical integration and corporate venture capital (Fairbairn and Reisman, 2024).

Start-ups face both challenges and opportunities within oligopolistic platformisation. Competing with established multinational agribusinesses, which possess superior resources, brand recognition and well-established customer bases, presents significant challenges (Atik, 2023; Hackfort, 2021; Verdonk, 2019). 'Scaling solutions and reaching customers pose additional challenges for many startups' (Expert 365 FarmNet, 2022). However, opportunities arise through collaboration with these dominant players, particularly by joining their platform ecosystems (Figure 1). For example, 'John Deere collaborates with more than 200 companies on its John Deere Operations Centre platform, many of which are startups' (Expert John Deere 2, 2024). These collaborations allow start-ups to leverage the extensive resources and reach of established agribusinesses.⁸ As a result, whilst competition with multinational agribusinesses remains challenging, start-ups find new opportunities through these partnerships, shifting the competitive landscape towards differentiation amongst start-ups themselves.

Meanwhile, Big Tech companies have grown to near-monopoly status in their respective areas (Kurban, 2024). Leveraging their market position, they have expanded into various sectors, disrupting industries with advanced AI and cloud computing (Kejriwal, 2023; Srnicek, 2017a). In 2023, AWS, Microsoft Azure, Oracle and Google Cloud, alongside IBM and China's Alibaba Cloud, Tencent Cloud and Huawei Cloud, held over 97% of the market share (Haranas, 2024). Recently, these providers have targeted the ag sector, recognising its potential for digital innovation and new markets. Beyond cloud computing and data analytics, they offer services to enhance digital agriculture. This strategic move aligns with oligopolistic platformisation, as Big Tech companies strengthen their control over essential infrastructures that agribusinesses rely on, deepening the collaboration between the two sectors and entrenching market power. For example, AWS has achieved widespread integration across the agri-food value chain, 'collaborating with both upstream and downstream agribusinesses' (Expert AWS, 2023). Additionally, AWS has created 'a marketplace where software and analytics startups can offer their solutions and reach a broader audience, increasing their impact on the industry' (Expert AWS, 2023). The AWS Marketplace is a digital catalogue that allows customers like agri-industry players to purchase and deploy third-party software and services to build solutions on the AWS platform (Amazon Web Services, n.d.). It connects buyers and sellers, establishing two-sided markets that include both multinational agribusinesses and start-ups, facilitating valuable exchange. Similarly, Google Cloud collaborated with BASF to introduce a generative AI chatbot service for xarvio users in

Japan (BASF, 2024), further extending Big Tech's influence within the ag sector.

Datafication

Datafication is a critical mechanism driving the platformisation of the ag sector, as it transforms previously unquantifiable aspects of farming into measurable digital data. This mechanism involves turning subjects like farmers and their performance, objects like weather, soil and plant health, and practices like harvesting and irrigation into digital data. Whilst agribusinesses, public institutions and ag extensionists have been collecting data about farms and their performance for decades, datafication has introduced Big Tech companies as new stakeholders in the ag sector, producing new types of data (Expert BMEL, 2022). These companies offer predictive analytics for ag production, applying data analytics, machine learning and predictive models for optimising farming practices.

Unlike the platformisation observed in other industries, where a single platform often emerges, datafication in the ag sector is shaped by multiple incumbent firms that maintain control over competing platform ecosystems. For example, in industries like urban transportation, sectoral platforms such as Uber consolidate and control all relevant data flows. In contrast, the ag sector remains divided into silos, with each incumbent agribusiness building and controlling its platform. This creates significant barriers to seamless data integration and leads to sectoral fragmentation, forcing farmers and other stakeholders to navigate a landscape of competing platforms with incompatible data protocols, tools and restrictions.

Data capturing

Data capturing is an essential component of datafication in the ag sector, involving the collection of vast amounts of agronomic data through farm equipment, sensors, satellites and other digital tools. This process relies on both the technological capabilities of ag machinery and human inputs, such as manual data entry. In crop agriculture, farmers and agribusinesses need to actively capture data through ag machinery and hardware devices, unlike other societal sectors, where data is often a by-product of using a service. Companies like John Deere and CLAAS have equipped their tractors and combine harvesters with global positioning systems and real-time sensors that collect farming data, including field preparation, irrigation, sowing, application of agrochemicals and harvesting (Expert John Deere, 2023; Expert 365 FarmNet, 2022). Sectoral ag platforms operated by agrochemical and seed companies currently adopt two strategies to collect field-specific data. They collaborate with ag equipment manufacturers to integrate machine data into their platforms (Figure 1) or use their proprietary data-capturing technologies to

ensure compatibility between machines from different manufacturers (Expert BASF, 2023; Expert Climate FieldView, 2022). For instance, BASF's xarvio CONNECT or Bayer's FieldView Drive are hardware technologies that can be mounted on the cabin of any tractor, exchanging application data between terminal and platform or capturing machine and field data through wireless data streaming using geographic information systems and global positioning systems.

Platform operators combine these captured data in real-time with company-relevant data (e.g. information about seeds and agrochemicals) and public data (i.e. weather, climate, geophysical data and country-specific regulations) for further analysis (Expert BASF, 2023; Expert Climate FieldView, 2022). Furthermore, some platforms require farmers to manually input their data, and the efficacy of predictive analytics is contingent upon the accuracy and quality of the data provided by the farmers (Expert Climate FieldView, 2022).

Data circulation

Data circulation, another sub-mechanism of Van Dijck et al.'s (2018) datafication, emphasises how digital platforms exchange and combine vast datasets. In the ag sector, agribusinesses form ecosystems that enable data sharing to enhance network effects. They also circulate data with Big Tech to improve their data analytics. Figure 1 illustrates the collaborative and competitive dynamics amongst agribusinesses, each forming distinct clusters of data-sharing partnerships serving a unique brand ecosystem whilst also creating silos that limit full interoperability.⁹ These partnerships aim to strengthen network effects, where the value of a platform increases as more participants – farmers, agribusinesses and service providers – contribute to and utilise its data. Enhancing network effects for sectoral platforms is essential for their successful adoption amongst farmers, and partnerships between agribusinesses play a key role in this process (Expert BASF, 2023; Expert Climate FieldView, 2022; Expert John Deere, 2023). For instance, John Deere connects to platforms like Bayer's Climate FieldView, Corteva's Granular Insights and BASF's xarvio. By collaborating with multiple partners, John Deere expands the amount of data circulating through its platform, making it more attractive for farmer adoption.

Cross-industry partnerships, such as those between John Deere and Bayer's Climate FieldView, demonstrate how ag machinery and agrochemical/seed companies collaborate to offer integrated solutions. Although Bayer developed the FieldView Drive to capture machine and field data, it collaborates with ag machinery companies like CLAAS, John Deere and AGCO, broadening the platform's appeal through compatibility with different equipment. This facilitates data sharing and optimises ag practices across diverse operations. These strategic partnerships extend to other

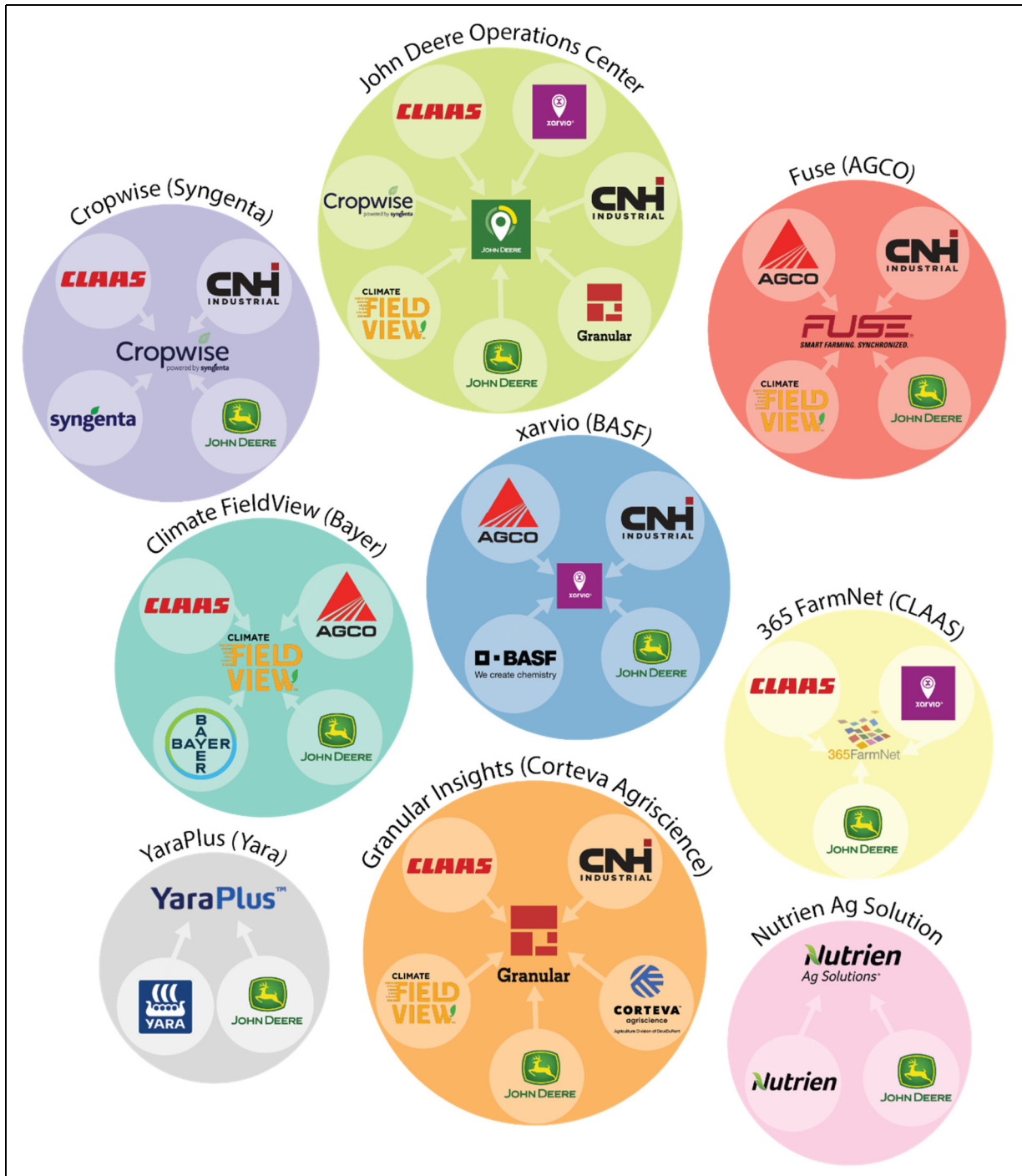


Figure 1. Platform ecosystems amongst sectoral ag platforms. This figure illustrates the fragmented data-sharing options amongst multinational upstream companies, highlighting both collaboration and competition within distinct platform ecosystems. Focusing on the major agribusinesses and excluding start-ups for clarity, the visualisation demonstrates how each company forms its cluster with specific integrations. It underscores the strategic behaviours within the sector, where selective data sharing both reinforces market power and restricts broader interoperability, as collaboration coexists with competition.

agrochemical and seed companies, crop insurance companies and sensor and satellite firms (Expert Climate FieldView, 2022; Expert John Deere, 2023), which are not mapped in this network visualisation. As mentioned,

John Deere's platform allows farmers the choice to share data with various service providers, creating new opportunities for start-ups to leverage established networks and customer bases (John Deere, 2024).

Whilst agribusinesses collaborate to enhance network effects and farmer adoption, they simultaneously compete for dominance within the platform ecosystem. Agribusinesses race to become central hubs for ag data by withholding certain types of data to maintain competitive advantages, leading to data silos that prevent full interoperability (Hackfort, 2023; Kenney, Visser et al., 2021). Figure 1 highlights the fragmented nature of platform ecosystems, illustrating that not all companies share data with each other, and some, like John Deere, dominate multiple ecosystems with greater access to data. This strategy reflects the intense competition amongst agribusinesses to establish a strong market presence, with firms positioning themselves to become (one of) the dominant ecosystems. Access to more data enhances economies of scale and provides a data advantage, allowing for more accurate analytics and superior services, thereby strengthening the market position (Atik and Martens, 2021).

Furthermore, data circulation between multinational agribusinesses and infrastructural platforms like Microsoft Azure, Google Cloud and AWS occurs as agribusinesses leverage these platforms to analyse, manage and store ag data. These cloud-based services enable agribusinesses to utilise AI for data analysis and refinement, facilitating real-time, on-farm decision-making through cloud and edge computing (Expert AWS, 2023; Expert Google, 2023; Expert Microsoft 2, 2023). Infrastructural platforms play a pivotal role in transforming raw data collected by farmers and agribusinesses into actionable ag analytics to optimise farming operations (Expert Microsoft, 2022). Amazon, Google and Microsoft enable agribusinesses to combine farm-specific data, public data, agrochemical data and ag machinery data to provide data-driven insights. Their cloud computing capabilities facilitate ‘real-time on-farm data analytics on a global scale, offering a significant advantage to multinational agribusinesses seeking to scale up their operations’ (Expert AWS, 2023).

Up to now, the partnerships between agribusinesses and Big Tech have resulted in a dynamic where Big Tech supports the market dominance of agribusinesses without directly challenging or disrupting their power.

Selection

The mechanism of selection, a critical factor in the platformisation of the ag sector, has undergone a significant transformation. Traditionally based on expert know-how and farmers’ experience, selection is now increasingly driven by algorithm methods, where platforms prioritise and filter information through data analysis rather than human expertise. These algorithms leverage predictive analytics to forecast future choices and trends by analysing historical site-specific patterns of farms or climate conditions (Expert 365 FarmNet, 2022; Expert Climate FieldView, 2022; Expert Microsoft, 2022). For example, digital ag platforms advise farmers about various farming activities, e.g. weed

control based on real-time, site-specific conditions on the farm. This shift centralises decision-making in the hands of platforms, reducing the role of human judgment in favour of algorithmic-driven selection.

A key sub-mechanism of selection is moderation, where platforms actively manage content and user access, controlling what information is made available and how it is presented (Van Dijck et al., 2018: 44). In the context of oligopolistic platformisation, moderation is used to reinforce market dominance by curating recommendations and information that favour the platform owner’s products and services, often creating information asymmetries that limit farmers’ ability to make fully informed decisions, as well as vendor lock-ins that tie farmers to specific ecosystems. For example, Bayer’s Climate FieldView exemplifies how moderation is employed to extend or at least secure its market position. The platform limits its advice and recommendations to the company’s products on its platform Climate FieldView (Expert Climate FieldView, 2022).¹⁰ Whilst this focus may stem from the company’s expertise in its products, such selective guidance can significantly influence farmers’ decision-making processes. This bias leads to information asymmetries between farmers and agribusinesses, thereby potentially hindering optimal choices, especially when farmers are unaware of it.

Similarly, ag machinery platforms like John Deere use moderation to bind farmers into their machine ecosystems through vendor lock-ins. Machinery from the same company is designed for seamless integration within one brand’s platform, whilst intentionally limiting compatibility with equipment from other manufacturers (Hackfort, 2023). Each manufacturer uses a proprietary data format, making it challenging to evaluate and analyse data from different manufacturers within a single platform (Expert 365 FarmNet, 2022; Expert DBV, 2022; Expert Microsoft 2, 2023). This selective data exchange results in data silos, where full interoperability is prevented. Consequently, analysing data from different ag machinery brands within a single platform is only partially possible (Kalmar et al., 2022). ‘This incentivizes farmers to purchase all their farm machinery from a single company, streamlining data integration and operation within one brand’s platform and creating lock-in effects that make it difficult for farmers to switch to a competitor’s machinery’ (Expert DBV, 2022). In sum, the mechanisms of datafication and selection in oligopolistic platformisation highlight the tension between collaboration and competition within sectoral ag platforms. Whilst collaboration occurs through data sharing, selection sustains competition amongst agribusinesses by creating information asymmetries and vendor lock-ins that restrict farmers’ choices and reinforce firms’ market power.

Commodification

The commodification mechanism highlights how platforms turn user data and interactions into economic value and

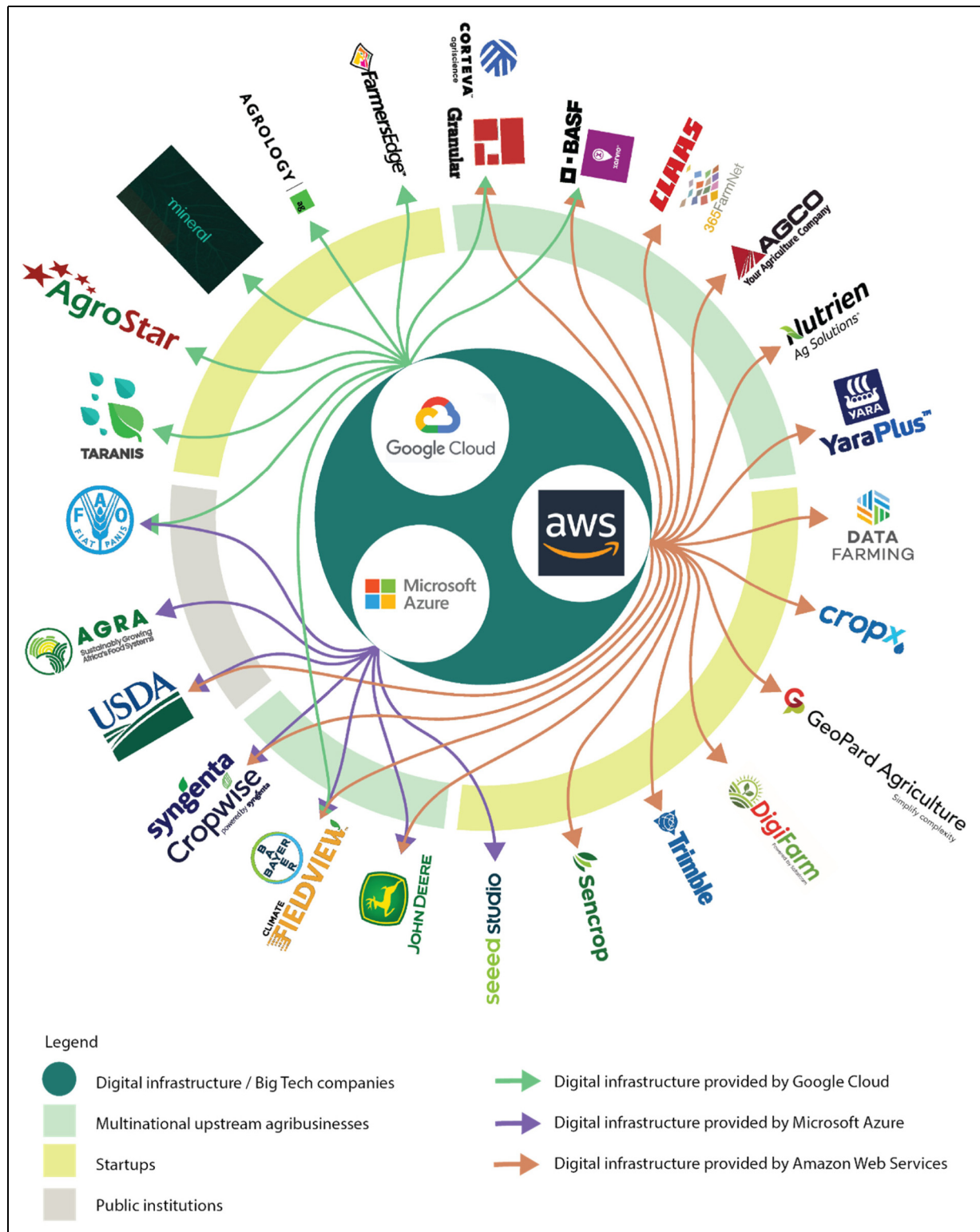


Figure 2. Collaboration between Big Tech companies, multinational agribusinesses, start-ups and public institutions. This figure illustrates economic interactions in the ag platform industry, highlighting how infrastructural platforms provided by Google Cloud, Microsoft Azure and AWS support various sectoral ag platforms. Whilst not fully comprehensive, it represents an overall picture of the economic relationships within the industry. AWS, Amazon Web Services.

marketable products via tradeable commodities and services, often disrupting traditional firms. However, in the ag sector, oligopolistic platformisation allows established companies to strengthen their market position rather than being disrupted. Multinational agribusinesses and Big Tech companies collaborate to commodify personalised ag data, providing data-driven insights to optimise crop yields whilst managing agrochemical inputs. Through these platforms, they aim to centralise digital ag services and make platforms the primary organisational form. Big Tech companies generate revenue through partnerships with sectoral ag platforms, whilst sectoral platforms rely on cross-funding from their agribusinesses' core businesses, as many are not yet profitable.

Commodification of ag data by infrastructural ag platforms

Microsoft Azure, AWS and Google Cloud form the backbone of the digital infrastructure in digital agriculture, serving multinational agribusinesses, start-ups and public institutions. These platforms offer cloud computing and data analytics services, critical for digital agriculture. Figure 2 illustrates how Amazon, Microsoft and Google have successfully integrated their services with nearly every multinational agribusiness, many start-ups and several public institutions. Although Big Tech may not have direct access to agronomic data, these partnerships still allow them to gain a significant data advantage, improving their algorithms and infrastructure by processing vast amounts of information, thereby strengthening their position in the ag sector.

Similar to market concentration effects seen in other industries, Big Tech companies have become indispensable partners in digital agriculture. As the scalability of digital infrastructure is key to competitiveness, more agribusinesses and start-ups are migrating to these platforms. Cloud platforms, as emphasised by Srnicek (2017a: 38), have transformed various industries by facilitating the outsourcing of significant information technology functions. In the ag sector, agribusinesses increasingly opt for cloud computing infrastructure over traditional on-premises data centres. By doing so, these businesses can reallocate their information technology personnel to more strategic endeavours, thus amplifying their focus on high-value activities. Agribusinesses 'can use these resources on an as-needed basis, scaling up or down capacities to manage data flows corresponding to seasonal workloads, such as during peak planting or harvesting periods' (Expert AWS, 2023). Even agribusinesses with their digital infrastructure benefit from the enhanced capabilities of Big Tech's infrastructural platforms (Expert AWS, 2023; Expert Google, 2023; Expert Microsoft, 2022).

The data analytics services provided by these platforms enable agribusinesses to efficiently process vast amounts

of data. To enhance AI capabilities, Microsoft and Google have developed test farms and specialised hardware, such as Google's Mineral rover (Mineral-X, 2023; Microsoft Research, 2021).¹¹ These initiatives allow Big Tech companies to independently develop and refine their data analytics and algorithms without relying on data from agribusinesses. The ultimate goal is to offer advanced digital infrastructure on lease to agribusinesses in the long term (Expert Google, 2023; Expert Microsoft, 2022; Expert Microsoft 2, 2023). Whilst concerns have been raised that Big Tech might access ag data for their use or integrate it with consumer data (GRAIN, 2021; Prause et al., 2021), this is not the case; e.g. companies like Microsoft do not have access to the content of the data (Expert Microsoft 2, 2023).

Commodification strategies by sectoral ag platforms

Sectoral ag platforms, operated by multinational agribusinesses, complement their traditional business models, such as selling agrochemicals or ag machinery. In oligopolistic platformisation, these platforms help incumbents strengthen their market position by integrating data-driven services with their core products. The aim is to centralise digital ag services and capture value, offering solutions such as data-driven ag solution packages, multisided markets connecting start-ups with farmers, product-as-a-service approaches and tools for carbon emissions monitoring in agriculture.

Agrochemical companies face regulatory pressure on their products, particularly concerning environmental impacts, along with increasing competition from generic products due to patent expirations (European Commission, 2022; IHS Markit, 2022). In response, they are shifting from their traditional models of producing and distributing large amounts of agrochemical products to service-oriented solutions models. Whilst agrochemical inputs remain a crucial part of their business, these 'data-driven agricultural solutions packages' integrate agronomic, weather and space data with advice tailored to their product offerings, such as seeds and agrochemicals (Independent Agribusiness Consultant, 2022). Ag platforms are 'primarily designed to complement their companies' core business by integrating the use of their products into the solutions provided by their platforms' (Expert 365 FarmNet, 2022). The 'data-driven agricultural solutions packages' serve a dual purpose: advancing crop management through precise data analytics and strategically repositioning the entire agrochemical and seed portfolio, including off-patent products:

These solutions-oriented approaches help mitigate the impact of patent expirations by enhancing the value and differentiation of off-patent products through integrated, data-driven services resulting in complete crop management

offerings. In regions with stringent environmental regulations, these digital solutions allow companies to defend their business by promoting practices that reduce the use of agrochemicals thereby adhering to sustainability standards. This evolution towards a solution-based model, leveraging the convergence of digital agriculture and traditional inputs, will potentially transform the agricultural input industry profoundly (Independent Agribusiness Consultant, 2022).

Multinational agribusinesses are also building multi-sided markets within their platform ecosystems, connecting start-ups, farmers and external services. These ecosystems, owned and controlled by the agribusinesses, serve as central hubs through which all ag data flows, giving platform owners the power to determine which start-ups can participate and potentially limiting access. At the same time, they offer an entry point into the digital agriculture market for selected providers. For example, as discussed in the previous section on datafication, John Deere Operations Centre allows data sharing with over 200 digital agriculture service providers, transforming the platform into a marketplace for digital agriculture. Leading companies such as John Deere aim to make their platforms the primary organisational form in the industry.

Some sectoral platforms adopt a product-as-a-service approach (Lacy and Rutqvist, 2015), selling a guaranteed outcome instead of the product itself (Expert BASF, 2023). For example, BASF commodifies farm know-how by complementing or replacing farmers' knowledge and experience about farming practices with algorithms to optimise ag production like applying agrochemicals and irrigation or deciding on harvesting time based on real-time field conditions. The value proposition of xarvio Healthy Fields guarantees farmers a leaf health of more than 80% based on data-driven, field-specific advice. In the case of damage, farmers are financially compensated at the company's guarantee promise (Expert BASF, 2023).

Agribusinesses also attempt to capitalise on the growing trend of reducing carbon emissions in the ag sector by developing tools to accurately measure and monitor the effectiveness of these efforts. Governmental bodies like the European Commission, the United States Department of Agriculture, and the Canadian government have implemented proactive initiatives to bolster carbon sequestration and reduce greenhouse gas emissions (European Commission, 2021; Government of Canada, 2022; USDA, 2021). Multinational agribusinesses and start-ups, including Bayer, BASF, Yara, Corteva Agriscience, John Deere and Farmers Edge, are currently working on digital solutions to measure farms' carbon footprints. Driven by policies and subsidies for carbon sequestration, this allows farmers to earn income through carbon credits. If successful, efforts may become part of the agribusinesses' data-driven ag solutions packages.

Notably, most sectoral ag platforms have yet to transform their services into profitable commodities. Currently, they remain in the investment phase, cross-funded by the core businesses of the respective multinational agribusiness (Expert John Deere, 2023; Expert 365 FarmNet, 2022). Oligopolistic platformisation enables this prolonged investment period, as incumbents can cross-fund their digital platforms, ensuring they remain competitive until profitability is achieved. As Cusumano (2022) and Srnicek (2017) have emphasised, unprofitable platform businesses are common, with failure more frequent than success, yet investors continue to fund these platforms due to the anticipated winner-takes-most-dynamics. Unlike unprofitable platforms in other sectors that often rely on venture capital (Srnicek, 2017b: 257), ag platforms benefit from the financial backing of multinational agribusinesses.

To navigate these financial challenges, many sectoral platforms adopt a 'freemium platform model', offering basic services for free, with premium features available for a fee (Van Dijck et al., 2018: 39). However, 'these fees do not cover the platform's operating expenses' (Expert 365 FarmNet, 2022). This competitive pricing strategy attracts users and can lock them into the ecosystem, similar to other industries. If leading digital ag platforms emerge, they could eventually raise their prices whilst retaining customers, capitalising on network effects like Uber or Netflix. Currently, 'no platform market leader exists in the ag sector as each sectoral platform promotes its company's core business, such as selling agrochemicals or machinery' (Expert 365 FarmNet, 2022). The parallel existence of multiple platform ecosystems suggests a tendency towards platform fragmentation in the ag sector (Figure 1).

Discussion

Our findings indicate that platformisation in the ag sector involves significant collaboration between multinational upstream agribusinesses and Big Tech companies, blurring traditional industry boundaries. Whilst Prause et al. (2021) have raised concerns about Big Tech's potential threat to agribusinesses and Maschewski and Nosthoff (2022) note that agribusinesses heavily rely on Big Tech, our study demonstrates that these views underestimate how, enabled by Big Tech, agribusinesses can enhance digital ag capacities, generating mutual benefits and creating what we term oligopolistic platformisation.

Datafication has led to multiple, fragmented platform ecosystems, each owned and controlled by multinational upstream agribusinesses. These platforms enable farmers to share their data, thereby increasing platform value through network effects. This aligns with previous studies, which have shown that data sharing can enhance platform value by amplifying network effects (Boudreau and Jeppesen, 2015; Rochet and Tirole,

2002; Schilling, 2002). However, despite this potential, fragmentation persists as each agribusiness maintains control over its data flows and platforms, fostering competition alongside collaboration. Oligopolistic platformisation, in this case, hampers the development of a unified data ecosystem, reinforcing data silos that limit interoperability. Cross-industry partnerships, such as those between agrochemical and machinery companies, illustrate how integrated data solutions provide competitive advantages. Yet, each platform aims to become the dominant platform ecosystem, driven by winner-takes-most dynamics.

Selection mechanisms in oligopolistic platformisation reinforce power relations between agribusinesses and farmers through information asymmetries and vendor lock-ins hindering the latter from switching to potentially better and cheaper alternatives (Atik, 2023; Hackfort, 2023). Ag machinery manufacturers often create technical barriers to agronomic data transfer, resulting in a lack of interoperability and the absence of a data interface, incentivising farmers to stick with a single provider (Atik, 2022; Kritikos, 2017). This strategy helps companies preserve their unique selling propositions and proprietary digital ecosystems, but it also concentrates data in the hands of a few large companies, impeding potential efficiencies (Kenney, Visser et al., 2021). Though datafication fosters collaboration, competition persists through selection mechanisms. Future research should address evolving mechanisms under regulations like the EU Data Act, which mandates data access and interoperability (European Commission, 2024).

Our findings on commodification in the ag sector are divergent. Whilst Big Tech companies have commodified their services, sectoral platforms remain largely unprofitable. Oligopolistic platformisation enables this prolonged investment period, as incumbents can cross-fund their digital platforms, ensuring they remain competitive until profitability is achieved. Infrastructural platforms from Big Tech support agribusinesses, start-ups and public institutions, mirroring trends in other sectors where Big Tech companies form the core of the digital ecosystem (Van Dijck et al., 2018). Unlike in many other sectors where commodification is disruptive, in the oligopolistic platformisation of the ag sector, multinational agribusinesses maintain their core business whilst integrating new services. These services include data-driven ag solutions, multisided markets, product-as-a-service models and carbon monitoring tools. Traditional ag machinery manufacturers like John Deere have expanded beyond manufacturing to offer integrated solutions combining software, hardware and services into a comprehensive ecosystem for farmers. Similarly, agrochemical companies like Bayer have shifted from selling large volumes of agrochemicals to providing comprehensive data-driven solutions. This deeper integration of seeds, agrochemicals, biotechnology and

digital agriculture reinforces the dominant position of multinational agribusinesses over ag information, knowledge of production and distribution.

Oligopolistic platformisation has significant implications for stakeholders in the ag sector. The collaboration between Big Tech and multinational agribusinesses raises entry barriers for competitors, as their combined technological and economic strength creates an environment difficult for emerging companies to penetrate. Agribusinesses cross-finance platforms through their core business revenue, invest heavily in R&D and offer freemium versions, making it harder for new entrants to challenge their dominance. However, oligopolistic platformisation also presents new opportunities for start-ups. By focusing on niche areas and collaborating with large agribusinesses, start-ups can integrate their solutions into larger platform ecosystems. These collaborations are often welcomed, as start-ups add value to the platforms – provided they do not pose a competitive threat to the established giants. For example, ‘some agribusinesses, whilst strong in core areas, do not cover all agricultural tasks or regional solutions with in-house technologies or services, leading them to collaborate extensively with startups and other firms to fill these gaps’ (Expert John Deere 2, 2024). Leveraging the networks and resources of multinational agribusinesses enhances startups’ growth and market reach. This dual dynamic of entry barriers combined with collaboration underscores the complex impact of platformisation on the ag sector, offering both challenges and opportunities for new entrants.

Furthermore, potential negative impacts on farmers may arise. Whilst platforms provide immediate benefits through data services and solutions, they can also create or deepen farmers’ dependency and reduce autonomy (Rotz, Gravely et al., 2019). As large entities dominate, farmers face fewer choices for digital tools, increasing their reliance on oligopolistic companies. This dependency may lead to unfavourable terms, like higher costs or restrictive data-sharing conditions. The power imbalance enables these companies to prioritise their business models over farmers’ needs, potentially reducing low-profit margins and limited bargaining power. In this sense, oligopolistic platformisation risks locking farmers into ecosystems controlled by a few large companies.

Lastly, platform and data fragmentation remain issues, as each sectoral platform prioritises its company’s core business, such as selling agrochemicals, seeds or machinery. This leads to siloed data systems, potentially limiting innovation, reducing efficiency and slowing the adoption of digital tools in farming communities (GAO, 2024; Kenney, Visser et al., 2021). This contrasts with winner-take-all platforms in other industries that drive rapid technological progress (Evens and Donders, 2018). Without greater data-sharing practices, the sector may risk missing the full potential of a cohesive digital ecosystem.

Conclusion and outlook

Analysing the emergence of the Ag-Big Tech Complex within the broader context of ag industrialisation, we explore how the platform economy (Kenney and Zysman, 2016) has entered the ag sector. Collaboration between multinational agribusinesses and Big Tech companies blurs traditional industry boundaries, creating mutually beneficial economic relationships within a concentrated market. We have developed the concept of ‘oligopolistic platformisation’ to describe how digital platforms integrate into established oligopolistic markets. Our findings indicate that Big Tech and multinational agribusinesses attempt to collaboratively establish digital platforms as the core organisational form of digital agriculture, aiming to centralise services through their platforms. However, despite these efforts, most sectoral platforms are not yet profitable, raising questions about the long-term viability of their commodification strategies. Still, this process, shaped by pre-existing market structures, will likely reinforce the market position of established companies.

Our study acknowledges several limitations due to the rapidly evolving nature of digital agriculture. Whilst we identified both entry barriers and new opportunities for start-ups, the long-term implications remain uncertain. Additionally, many platforms by multinational agribusinesses are not yet profitable, and the success of commodification strategies is unclear. More research is needed to fully understand these dynamics and their future impact. Whilst expert insights have been valuable, we acknowledge that more direct citations of these interviews could strengthen our conclusions, yet were sometimes limited by confidentiality concerns or experts’ hesitation to disclose specific details. Despite these constraints, our research provides robust insights into the ag-Big Tech Complex and lays a foundation for future studies on digital platforms in agriculture.

Policy and regulatory implications arise from the high concentration of power in Big Tech and agribusinesses. Market regulations may be necessary as the Ag-Big Tech Complex strengthens its dominance. However, regulating platforms is complex, as traditional approaches to competition, labour laws, privacy and taxation have proven inadequate for multinational firms in a rapidly advancing technological era (Tirole, 2023). The absence of a supranational regulatory authority, coupled with varying geopolitical interests and diverse regulatory approaches amongst major players like the USA, China and Europe (Huang and Mayer, 2023; Van Dijck and Lin, 2022; O’hara and Hall, 2018), complicates the regulatory landscape for ag platforms. Future research should examine additional case studies of oligopolistic platformisation and develop effective regulatory frameworks to ensure the benefits of ag platforms are widely distributed whilst mitigating risks.

Acknowledgments

The authors would like to extend sincere gratitude to all the experts who generously shared their time and insights during the interviews. Their willingness to engage in thoughtful discussions greatly enriched the research.

Data availability

Supplementary documents are included in a folder containing the raw network data used to develop Figures 1 and 2, two exemplary interview guides, and a list of all observed field activities. Please note that the transcripts of the qualitative interviews cannot be shared to protect the anonymity of the participants.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This work was supported by the Open Access Publication Fund of the University of Bonn. Grateful acknowledgement is also given to the PhenoRob Cluster for Excellence at the University of Bonn for its valuable support for this research.

ORCID iDs

Monja Sauvagerd  <https://orcid.org/0000-0002-7764-9137>
 Maximilian Mayer  <https://orcid.org/0000-0002-1857-1413>
 Monika Hartmann  <https://orcid.org/0000-0002-3631-164X>

Supplemental material

Supplemental material for this article is available online.

Notes

1. We focus on the largest multinational upstream agribusinesses, which produce and supply agricultural inputs like seeds, agrochemicals and machinery.
2. Big Tech companies, known for their enormous market capitalisation, global reach and vast user bases, include the influential GAFAM companies: Google, Apple, Facebook, Amazon and Microsoft.
3. We focused on commodity cropland farming systems, particularly those involving major commodities like oil and grain seeds, due to their significant impact on food security, threatened by factors like land degradation, water scarcity and climate change (Grote et al., 2021). We acknowledge the relevance of digital tools in livestock agriculture, horticulture, and aquaculture and recognise the interconnected nature of the ag sector with the agri-food system, involving food processors, traders, distributors and consumers.
4. For the difference between sectoral and infrastructure platforms see: Van Dijck et al. (2018): 12–22.
5. Agronomic data refers to the information about activities and conditions on farm fields, including soil analysis, nutrient

information, hybrid selection, plant populations and yield data.

6. Supplementary documents are included in a folder containing the raw network data used to develop Figures 1 and 2, two exemplary interview guides, and a list of all observed field activities.
7. Bayer's acquisition of Climate FieldView during its merger with Monsanto prompted an anti-trust investigation by the European Commission. To address competition concerns, Bayer divested its digital platform xarvio to BASF, ensuring producers access to a variety of digital ag platforms (European Commission, 2018).
8. Nevertheless, in many cases, partnerships in digital agriculture tend to operate under terms established by dominant players who often influence the degree of access, data integration and interoperability available to each partner.
9. As of 2024, our network visualisation shows how farmers can choose to share data across various manufacturers and platforms. Similar to selecting apps in an app store, farmers can decide which company to share data with, choosing the platform services that best align with their needs. To focus on core data-sharing dynamics, the visualisation emphasises data circulation options among the largest multinational upstream agribusinesses, excluding start-ups.
10. The Bayer–Monsanto merger documents reveal a strategy to use digital agriculture to integrate input sales with tailored prescription services, aiming to protect revenue from potential losses due to reduced input use driven by precise digital recommendations (European Commission, 2018: Recitals 2712–2714).
11. In July 2024, Google sold its ag tech subsidiary, Mineral. The impact of this sale is still unclear, but in August 2024, Mineral announced a collaboration with John Deere, hinting at potential shifts in the sector (Grant, 2024).

References

- Amazon Web Services (n.d.) Digital commerce. <https://aws.amazon.com/de/solutions/agriculture/digital-commerce/> (accessed 15 July 2024).
- Atik C (2022) Towards comprehensive European Agricultural data governance: Moving beyond the 'data ownership' debate. *IIC – International Review of Intellectual Property and Competition Law* 53(5): 701–742.
- Atik C (2023) Addressing data access problems in the emerging digital agriculture sector: Potential of the refusal to deal case law to complement *ex-ante* regulation. *European Competition Journal*: 380–409.
- Atik C and Martens B (2021) Competition problems and governance of non-personal agricultural machine data. *Journal of Intellectual Property, Information Technology and Electronic Commerce Law* 12(3): 370–396.
- Bajari P, Chernozhukov V, Hortaçsu A, et al. (2019) The impact of big data on firm performance: An empirical investigation. *AEA Papers and Proceedings* 109: 33–37.
- Baldwin CY and Woodard CJ (2009) The architecture of platforms: A unified view. In: *Platforms, Markets and Innovation*. Research Collection School Of Information Systems, 19–44.
- BASF (2024) BASF collaborates with Google Cloud to launch Generative AI Chatbot Consultant Service for xarvio@ FIELD MANAGER users in Japan. https://www.basf.com/jp/en/media/news-releases/jp/2024/04/xarvio_gemini.html (accessed 5 June 2024).
- Bayer AG (2023) *Leaps by Bayer Annual Review 2023*. Leverkusen, Germany: Bayer AG.
- Boudreau KJ and Hagiu A (2008) Platforms, markets and innovation. In: *Platform Rules: Multi-Sided Platforms as Regulators*. Cheltenham, UK: Edward Elgar Publishing, 163–191.
- Boudreau KJ and Jeppesen LB (2015) Unpaid crowd complementors: The platform network effect mirage. *Strategic Management Journal* 36(12): 1761–1777.
- Bronson K (2019) Looking through a responsible innovation lens at uneven engagements with digital farming. *NJAS: Wageningen Journal of Life Sciences* 90-91(1): 1–6.
- Bronson K and Knezevic I (2016) Big Data in food and agriculture. *Big Data & Society* 3(1): –5..
- Bronson K and Sengers P (2022) Big tech meets big ag: Diversifying epistemologies of data and power. *Science as Culture* 31(1): 15–28.
- Ciligit C (2020) What Is Platform Governance and Why Is It a Big Deal? <https://learn.g2.com/platform-governance> (accessed 19 July 2022).
- Clapp J, Newell P and Brent ZW (2018) The global political economy of climate change, agriculture and food systems. *The Journal of Peasant Studies* 45(1): 80–88.
- Clapp J and Ruder S-L (2020) Precision technologies for agriculture: Digital farming, gene-edited crops, and the politics of sustainability. *Global Environmental Politics* 20(3): 49–69.
- Clifford N, French S and Valentine G (2010) *Key Methods in Geography*. London: Sage Publications.
- Cusumano MA (2022) The evolution of research on industry platforms. *Academy of Management Discoveries* 8(1): 7–14.
- Cusumano MA, Gawer A and Yoffie DB (2019) *The Business of Platforms: Strategy in the Age of Digital Competition, Innovation, and Power*, 1st edn New York, NY: Harper Business, an imprint of HarperCollinsPublishers.
- Drach U, Halachmi I, Pnini T, et al. (2017) Automatic herding reduces labour and increases milking frequency in robotic milking. *Biosystems Engineering* 155: 134–141.
- European Commission (2018) *Case M.8084 – BAYER/ MONSANTO Merger Procedure Regulation (EC) 139/2004, 1709 final*. Brussels: European Commission. https://ec.europa.eu/competition/mergers/cases1/202150/M_8084_8063752_13335_9.pdf (accessed 27 September 2024).
- European Commission (2021) *Communication from the Commission to the European Parliament and the Council – Sustainable Carbon Cycles*. European Commission.
- European Commission (2022) The sustainable use of pesticides: Use of chemical pesticides to be cut by 50% for the good of the planet and its people. <https://ec.europa.eu/newsroom/sante/items/750744/en>.
- European Commission (2024) Data Act enters into force: what it means for you. https://commission.europa.eu/news/data-act-enters-force-what-it-means-you-2024-01-11_en.
- Evens T and Donders K (2018) *Platform Power and Policy in Transforming Television Markets*. Cham: Palgrave Macmillan.
- Expert 365 FarmNet (2022) Interview with 356 FarmNet/CLAAS.

- Expert AWS (2023) Interview with AWS Cloud for Agriculture.
- Expert BASF (2023) Interview with Xarvio.
- Expert BMEL (2022) Interview with Germany's Federal Ministry for Food and Agriculture.
- Expert Climate FieldView (2022) Interview with Bayer/Climate FieldView.
- Expert DBV (2022) Interview German Farmers' Association.
- Expert Google (2023) Interview with Google Cloud.
- Expert John Deere 2 (2024) Interview with John Deere Manager Solution Controls Strategy.
- Expert John Deere (2023) Interview with John Deere Intelligent Solutions Group, Kaiserslautern.
- Expert Microsoft 2 (2023) Interview with Microsoft.
- Expert Microsoft (2022) Interview with Microsoft Azure.
- Fairbairn M and Reisman E (2024) The incumbent advantage: Corporate power in agri-food tech. *The Journal of Peasant Studies*: 1331–1354.
- Finger R, Swinton SM, El Benni N, et al. (2019) Precision farming at the nexus of Agricultural production and the environment. *Annual Review of Resource Economics* 11(1): 313–335.
- GAO (2024) *Precision Agriculture – Benefits and Challenges for Technology Adoption and Use*. GAO-24-105962, January. United States Government Accountability Office. <https://www.gao.gov/assets/d24105962.pdf> (accessed 10 April 2024).
- Gawer A (2009) *Platforms, Markets and Innovation*, Paperback edition reprinted. Cheltenham: Edward Elgar.
- Gawer A (2021) Digital platforms and ecosystems: Remarks on the dominant organizational forms of the digital age. *Innovation*: 110–124.
- Gebbers R and Adamchuk VI (2010) Precision agriculture and food security. *Science* 327(5967): 828–831.
- Glaser BG and Strauss AL (1980) *The Discovery of Grounded Theory: Strategies for Qualitative Research*. 11th printing. New York: Aldine.
- Government of Canada (2022) Government of Canada announces up to \$182.7 million to partner organizations to help farmers lower emissions and improve resiliency to climate change. <https://www.canada.ca/en/agriculture-agri-food/news/2022/02/government-of-canada-announces-up-to-1827-million-to-partner-organizations-to-help-farmers-lower-emissions-and-improve-resiliency-to-climate-change.html> (accessed 23 June 2022).
- GRAIN (2021) *Digital control – How Big Tech moves into food and farming (and what it means)*. January. Barcelona, Spain.
- Grant E (2024) After a few billion plant images, and hundreds of experiments, Mineral is entering a new phase. <https://mineral.ai/> (accessed 9 October 2024).
- Grote U, Fasse A, Nguyen TT, et al. (2021) Food security and the dynamics of wheat and maize value chains in Africa and Asia. *Frontiers in Sustainable Food Systems* 4: 617009.
- Hackfort S (2021) Patterns of inequalities in digital agriculture: A systematic literature review. *Sustainability* 13(22): 12345.
- Hackfort S (2023) Unlocking sustainability? The power of corporate lock-ins and how they shape digital agriculture in Germany. *Journal of Rural Studies* 101: 103065.
- Hackfort S, Marquis S and Bronson K (2024) Harvesting value: Corporate strategies of data assetization in agriculture and their socio-ecological implications. *Big Data & Society* 11(1): 20539517241234279.
- Haranas M (2024) AWS, Microsoft, Google Lead Gartner's Cloud Services Magic Quadrant. <https://www.crn.com/news/cloud/2024/aws-microsoft-google-lead-gartner-s-cloud-services-magic-quadrant> (accessed 4 January 2024).
- Hein A, Schrieck M, Riasanow T, et al. (2020) Digital platform ecosystems. *Electronic Markets* 30(1): 87–98.
- Huang Y and Mayer M (2023) Power in the Age of datafication: Exploring China's global data power. *Journal of Chinese Political Science* 28(1): 25–49.
- IHS Markit (2022) *New Generics in Crop Protection 2022 Active ingredients coming off-patent 2020-2027*.
- Independent Agribusiness Consultant (2022) Interview with independent agribusiness consultant.
- John Deere (2021) John Deere Acquires Bear Flag Robotics to Accelerate Autonomous Technology on the Farm. <https://www.deere.com/en/news/all-news/2021aug5-bear-flag-robotics/> (accessed 30 November 2023).
- John Deere (2024) John Deere Announces Its 2024 Startup Collaborators. <https://www.deere.com/en/news/all-news/deere-announces-startup-collaborators/> (accessed 15 July 2024).
- Kalmar R, Rauch B, Dörr J, et al. (2022) Agricultural data space. In: Otto B, Ten Hompel M and Wrobel S (eds) *Designing Data Spaces*. Cham: Springer International Publishing, pp. 279–290.
- Katz ML and Shapiro C (1994) Systems competition and network effects. *Journal of Economic Perspectives* 8(2): 93–115.
- Kejriwal K (2023) *Artificial Intelligence for Industries of the Future – Beyond Facebook, Amazon, Microsoft and Google*. Marina Del Rey, California, USA: Springer.
- Kenney M, Rouvinen P, Seppälä T, et al. (2019) Platforms and industrial change. *Industry and Innovation* 26(8): 871–879.
- Kenney M, Visser MA and Zysman J (2021) The challenge of the digital agricultural revolution: A comparison between advanced economies and developing countries. *Berkely Roundtable on the International Economy*, October: 1–42.
- Kenney M and Zysman J (2016) The rise of the platform economy. *Issues in Science and Technology* 32(3): 61–69.
- Kenney M, Zysman J and Bearson D (2021) Transformation or structural change? What Polanyi can teach us about the platform economy. *Sociologica*: 227–240.
- Klerkx L and Rose D (2020) Dealing with the game-changing technologies of agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security* 24: –7..
- Kritikos M (2017) *Precision Agriculture in Europe – Legal, Social and Ethical Considerations*. PE 603.207, November. European Parliamentary Research Service – Scientific Foresight Unit (STOA), Brussels.
- Kurban C (2024) World's 22 Biggest Tech Companies of 2024. <https://userguiding.com/blog/biggest-tech-companies>.
- Lacy P and Rutqvist J (2015) The product as a service business model: Performance over ownership. In: *Waste to Wealth*. London: Palgrave Macmillan, UK, 99–114.
- Maschewski F and Nosthoff A-V (2022) Big tech and the smartification of agriculture: A critical perspective. In IT for Change (eds) *The State of Big Tech 2022, IT for Change*. SSRN: <https://ssrn.com/abstract=4080210>. Epub ahead of print 10 April 2022.
- Mayring P (2021) *Qualitative Content Analysis: A Step-by-Step Guide*. Thousand Oaks: Sage Publications.

- McCall GJ (1984) Systematic field observation. *Ann. Rev. Sociol.* 10: 263–282.
- McNunn G, Karlen DL, Salas W, et al. (2020) Climate smart agriculture opportunities for mitigating soil greenhouse gas emissions across the U.S. Corn-belt. *Journal of Cleaner Production* 268: 122240.
- Microsoft Research (2021) Precision agriculture uses computer science to make farms more efficient and reduce climate change. <https://www.microsoft.com/en-us/research/video/precision-agriculture-uses-computer-science-to-make-farms-more-efficient-and-reduce-climate-change/>.
- Mineral-X (2023) Mineral: Discovering the intelligence of plant-kind to feed and protect humankind. <https://x.company/projects/mineral/> (accessed 1 July 2023).
- Morgan D (2008) Snowball Sampling. In: *The SAGE Encyclopedia of Qualitative Research Methods: Snowball Sampling*. Thousand Oaks, California, USA: Sage Publications, 816–817.
- O'hara K and Hall W (2018) Four internets: the geopolitics of digital governance (CIGI Papers, 206) The Centre for International Governance Innovation (CIGI)/Chatham House, 28pp. CIGI Papers, 206. Chatham House: The Centre for International Governance Innovation (CIGI).
- Prause L, Hackfort S and Lindgren M (2021) Digitalization and the third food regime. *Agriculture and Human Values* 38(3): 641–655.
- Pylaniadis C, Osinga S and Athanasiadis IN (2021) Introducing digital twins to agriculture. *Computers and Electronics in Agriculture* 184: 1–25.
- Rietveld J and Schilling MA (2021) Platform competition: A systematic and interdisciplinary review of the literature. *Journal of Management* 47(6): 1528–1563.
- Robinson GM (2018) Globalization of agriculture. *Annual Review of Resource Economics* 10(1): 133–160.
- Rochet J-C and Tirole J (2002) Cooperation among competitors: Some economics of payment card associations. *The RAND Journal of Economics* 33(4): 549.
- Rotz S, Duncan E, Small M, et al. (2019) The politics of digital agricultural technologies: A preliminary review. *Sociologia Ruralis* 59(2): 203–229.
- Rotz S, Gravely E, Mosby I, et al. (2019) Automated pastures and the digital divide: How agricultural technologies are shaping labour and rural communities. *Journal of Rural Studies* 68: 112–122.
- Schilling MA (2002) Technology success and failure in winner-take-all markets: Testing a model of technological lock out. *Academy of Management Journal* 45: 387–398.
- Scott Morton FM, Crawford GS, Crémer J, et al. (2023) Equitable interoperability: The 'supertool' of digital platform governance. *Yale Journal on Regulation* 49: 1013–1055.
- Shapiro C and Varian HR (1999) *Information Rules: A Strategic Guide to the Network Economy*. Boston, Mass: Harvard Business School Press.
- Srnicek N (2017a) *Platform Capitalism*. Cambridge, UK: Polity Press Polity.
- Srnicek N (2017b) The challenges of platform capitalism understanding the logic of a new business model. *The Authors* 23(4): 254–257.
- Strömberg A and Howard P (2023) *Recent Changes in the Global Seed Industry and Digital Agriculture Industries*. Lund University and Michigan State University. Philhoward.net. <https://philhoward.net/2023/01/04/seed-digital/> (accessed 30 June 2023).
- Sykuta ME (2016) Big data in agriculture: Property rights, privacy and competition in ag data services. *International Food and Agribusiness Management Association* 19(a): 57–74.
- Tirole J (2023) Competition and the industrial challenge for the digital age. *Annual Review of Economics* 15(1): 573–605.
- Tsouvalis J, Seymour S and Watkins C (2000) Exploring knowledge-cultures: Precision farming, yield mapping, and the expert–farmer interface. *Environment and Planning A: Economy and Space* 32(5): 909–924.
- USDA (2021) USDA Announces New Initiative to Quantify Climate Benefits of Conservation Reserve Program. <https://www.fsa.usda.gov/news-room/news-releases/2021/usda-announces-new-initiative-to-quantify-climate-benefits-of-conservation-reserve-program> (accessed 23 June 2022).
- Van der Ploeg J (2010) The food crisis, industrialized farming and the imperial regime. *Journal of Agrarian Change* 10(1): 98–106.
- Van Dijck J and Lin J (2022) Deplatformization, platform governance and global geopolitics: Interview with José van Dijck. *Communication and the Public* 7(2): 59–66.
- Van Dijck J, Poell T and de Waal M (2018) *The Platform Society*. New York: Oxford University Press.
- Verdonk T (2019) Planting the seeds of market power: Digital agriculture, farmers' autonomy, and the role of competition policy. In: *Regulating New Technologies in Uncertain Times*—The Hague: T.M.C. Asser Press (Imprint), pp.105–132.
- Weersink A, Fraser E, Pannell D, et al. (2018) Opportunities and challenges for big data in agricultural and environmental analysis. *Annual Review of Resource Economics* 10(1): 19–37.
- Wolfert S, Ge L, Verdouw C, et al. (2017) Big data in smart farming – A review. *Agricultural Systems* 153: 69–80.