www.directivepublications.org

Annals Of
Agricultural Science And Technology

ISSN 2831-8129

Reasearch Article

Business Model Innovation In Agriculture 4.0: Implications Towards Servitization And Platformization.

Ricarda B. Bouncken, Beate Cesinger, Sven Laudien, Friedrich Bouncken.

Department of Business Administration VI Strategic Management and Organisation University of Bayreuth Bayreuth, Germany.
ourimpact.community eGbR Munich, Germany and Department of Business Administration VI Strategic Management and Organisation University of Bayreuth, Germany.
University of Bayreuth.

Abstract

AI, robotics, and digital platforms are reshaping agri-food systems and driving fundamental changes of business models. Drawing on business model theory, the activity-system perspective and business model innovation literature, this study conceptualizes the transformation of Agriculture 4.0 business models. Agriculture 4.0 transforms incumbent agritech business models by integrating connected machinery, analytics, and services into platform- and service-based architectures that enable continuous, outcome-linked value creation, delivery, and capture. These business model changes illustrate the shift from product-centric logics to data-driven, service- and platform-mediated logics in interconnected ecosystems. Innovation platforms accelerate this shift by embedding start-up technologies, fostering modular experimentation, and shaping architectural reconfigurations, positioning data, software, and ecosystem orchestration as central sources of competitive advantage. Platforms also generate power asymmetries, dependencies, and governance challenges, highlighting the openness-control dilemma in ecosystem design and governance. By framing Agriculture 4.0 as a systemic business model transformation rather than a mere technological upgrade, this study provides a conceptual foundation for understanding how AI- and robotics-enabled datafication reorganizes value creation, delivery, and capture, offering insights into opportunities, risks, and the distribution of power across contemporary agricultural ecosystems.

Keywords: smart farming; agriculture 4.0; digital transformation; business model innovation; platforms; servization; artificial intelligence and robotics; innovation ecosystems.

INTRODUCTION

The concepts smart farming and Agriculture 4.0 mark a transition from stand-alone mechanization toward cyber-physical farming systems in which connectivity, data infrastructures, and algorithmic control increasingly shape how agricultural production is planned, executed, and evaluated. Sensor-equipped machinery, cloud-based analytics, and AI-enabled decision support systems are becoming tightly integrated with robotics that can translate digital recommendations into field-level action (Uyar et al., 2024). These developments are visible across core operations, from irrigation and fertilization to crop protection and harvesting, where monitoring, prediction, and automation promise gains in timeliness, precision, and resource efficiency (Ahmed & Shakoor, 2025; Padhiary et al., 2024). For instance, computer vision embedded in machinery or robotic platforms enables digital weed detection, disease diagnosis, and crop maturity assessment (Assimakopoulos et al., 2024; Storm et al., 2024; Zhu et al., 2024). While both terms are used interchangeably, smart farming typically concentrates on the data-driven optimization of specific farming tasks through sensing technologies, analytics, and automated decision support. Agriculture 4.0 typically tends to denote the integration of cyber-physical systems, connectivity, and algorithmic control across agricultural value-creation activities, often spanning multiple actors and infrastructures. In the following we, for brevity, will use the term Agriculture 4.0.

Importantly, Agriculture 4.0 is not confined to the farm gate: it also connects field operations with downstream requirements such as traceability, documentation, and sustainability reporting, thereby linking production decisions to broader value-chain coordination (Spanaki et al., 2021). Market developments reflect the momentum of this transformation.

***Corresponding Author:** **Prof. Dr. Ricarda B. Bouncken.** Department of Business Administration VI Strategic Management and Organisation University of Bayreuth, Germany **TEL:** +49 921 554849, **Email:** bouncken@uni-bayreuth.de.
Received: 14-Jan-2026, Manuscript No. AAST - 5368 **; Editor Assigned:** 17-Jan-2026 **; Reviewed:** 29-Jan-2026, QC No. AAST - 5368 **; Published:** 28-Mar-2026. **DOI:** 10.52338/aast.2026.5368.
Citation: **Prof. Dr. Ricarda B. Bouncken.** Business Model Innovation In Agriculture 4.0: Implications Towards Servitization And Platformization. Annals Of Agricultural Science And Technology. 2026 March; 16(1). doi: 10.52338/aast.2026.5368.
Copyright © 2026 **Prof. Dr. Ricarda B. Bouncken.** This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

For example, the Agricultural Equipment Telematics Market Outlook 2033 estimates that connected machinery and related services have already reached substantial scale and are expected to grow markedly over the next decade (Sharma & Chandola, 2025). Yet diffusion is uneven, and the realized value of Agriculture 4.0 depends on contextual factors such as infrastructure quality, interoperability, and the fit of digital tools with farming routines and constraints. This unevenness makes business models, thus how technologies are packaged, supported, priced, and governed, central for understanding whether Agriculture 4.0 capabilities remain demonstrators or become widely adopted production solutions.

Digitalization has increased environmental dynamism and digital transformation is broadly recognized as a central driver of business model innovation, frequently resulting in significant reconfigurations of firms' value architectures (Bouncken et al., 2021). More recently, AI has been identified as a specific facilitator of business model innovation (Jorzik et al., 2024). Business models, defined as the architecture through which firms create, deliver, and capture value (Teece, 2010), are particularly exposed to the transformative effects of AI and robotics. Prior research emphasizes that AI reshapes business model components, including value propositions, infrastructures, customer relationships, and internal processes (Bahoo et al., 2023). As a result, firms move beyond transaction-based, product-centric logics toward digitally mediated forms of value creation (Şimşek et al., 2022) Incumbent firms are increasingly pressured to experiment with business model innovation (Clauss et al., 2020).

Despite rapid technological and market developments, research has offered limited insight into how Agriculture 4.0 reshape business models. This study addresses this gap by providing an integrative analysis of how the recent developments transform business models. We synthesize core technological developments in agriculture with business model theory and examine how service-oriented and platform-based models increasingly define competitive strategies among OEM agritechs. Building on the value creation-delivery-capture framework (Teece, 2010, 2018) and activity-system perspective (Amit & Zott, 2001, 2010; Zott & Amit, 2007), we shift the analytical focus from enabling technologies and single products toward connected, boundary-spanning configurations of activities, linkages, and control. Our model contributes to theory but also agricultural business that a key, but still under-specified implication of Agriculture 4.0 is the increasing service orientation of agricultural technology provision and business model innovation. Two business model innovations are particularly relevant in: service-oriented and platform-based models.

Service-oriented models leverage digital technologies to bundle physical products with data-driven services, enabling continuous revenue streams and long-term customer relationships rather than one-time sales (Baines et al., 2009; Vargo & Lusch, 2007). Machinery becomes connected and digitally augmented, value is no longer delivered only through equipment ownership and episodic repair. These service logics are implemented through subscription tiers, pay-per-use arrangements, retrofit-to-service pathways, and performance-linked pricing schemes, which lower adoption barriers for some farms while creating longer-term dependencies for others (Kohtamäki et al., 2019; Kohtamäki et al., 2020).

Platform-based models, in contrast, orchestrate multi-sided ecosystems through digital infrastructures that facilitate data exchange, interoperability, and coordination (Gawer, 2014; Tian et al., 2021) among farmers, equipment manufacturers, and input suppliers. Platform-based architectures facilitate the integration of third-party applications and services, expanding the range of complements that can be layered onto connected equipment (Gawer, 2014; Constantinides et al., 2018). Taken together, servitization and platformization are not peripheral add-ons; they are increasingly the commercialization vehicles through which Agriculture 4.0 is operationalized. Together, service-oriented and platform-based models support scalable innovation, continuous learning from field data, and more efficient coordination of agricultural operations and value chains, promising future growth and competitive advantage for OEMs, suppliers, service providers, and industrial users alike (Bouncken et al., 2021; Brousseau & Penard, 2007). Data becomes the central strategic resource of smart farming and Agriculture 4.0 (Uyar et al., 2024). While these models expand value propositions, they also centralize control over data and digital infrastructures, intensifying power asymmetries and raising questions about value distribution within agricultural innovation ecosystems (Clauss & Bouncken, 2019).

AGRICULTURE 4.0: ADVANCED DIGITAL TECHNOLOGY IMPLEMENTATION

Advances in AI (Kanbach et al., 2024) and robotics are reshaping agricultural production and the entire agricultural value chain in several ways. Agriculture 4.0 systems increasingly rely on ML, computer vision, robotics, and sensor-based infrastructures to support or autonomously execute real-time operational decisions and precision farming (Padhiary et al., 2024). ML models learn complex, non-linear patterns directly from large and heterogeneous datasets (Jordan & Mitchell, 2015). ML then enables AI systems to learn from agricultural data and improve processes without explicit programming (Padhiary et al., 2024).

Telematics hardware (including GPS, sensors, and connectivity) combined with big data infrastructures, cloud computing, and AI form the technological core of smart farming, enabling real-time data collection on soil, weather,

and crop conditions, as well as remote diagnostics, usage tracking, predictive maintenance, advanced data analytics, and automated operations (Finger, 2023; Javaid et al., 2022; Padhiary et al., 2025; Raj & Prahadeeswaran, 2025; Spagnuolo et al., 2025). Decision and prediction models analyze both real-time field data and historical data to enhance core activities from land preparation and irrigation scheduling to seeding, spraying, and crop monitoring (Spanaki et al., 2021). Another example is forecasting nitrogen needs by combining prior fertilization records with current canopy and soil measurements (Padhiary et al., 2024). Computer vision further enhances these capabilities by enabling robots and autonomous implements to detect weeds, identify disease symptoms, or assess fruit maturity directly in field conditions (Shamshiri, 2024). AI systems thus extend ML by autonomous decision-making, reasoning, and planning capabilities.

Robotics embodies the physical realization of ML and AI-driven decisions, converting digital inference into tangible real-world actions. Agricultural robots such as autonomous tractors, precision weeding systems, and robotic harvesters function as cyber-physical systems that tightly integrate perception, cognition, and actuation within unstructured and biologically variable environments (Bechar & Vigneault, 2016).

The digital transformation of agriculture marks a shift from experience-based farming toward precision agriculture grounded in data-driven, autonomous, and adaptive production systems (Bouncken & Schmitt, 2022; Uyar et al., 2024). This shift has given rise to Agriculture 4.0, defined by the integration of digital technologies, including the IoT, AI, robotics, and data analytics, into farming systems to enable real-time data generation and algorithmic decision-making (Javaid et al., 2022). In contrast to traditional farming, which relied on generalized heuristics and reactive responses, AI-enabled farming operates through continuous feedback loops that link embedded sensors, satellite imagery, connectivity, and cloud-based analytics to optimize production processes (Wolfert et al., 2017). These capabilities extend automation beyond discrete tasks such as planting, spraying, and harvesting to encompass integrated farm management processes, thereby reconfiguring industrial farming at the system level (Finger, 2023; Javaid et al., 2022; Spagnuolo et al., 2025). Machinery providers increasingly integrate hardware with proprietary software and data services, forming hybrid product–service–platform models (Finger, 2023). This shifts the focus in machinery design and manufacturing, and farming operation from machine plus operator toward machine plus software plus data plus autonomy (Padhiary et al., 2025; Spagnuolo et al., 2025). As a result, agricultural data ecosystems emerge as a central organizing infrastructure, coordinating technologies and actors and enabling productivity, efficiency, and sustainability outcomes associated with Agriculture 4.0 (Duguma & Bai, 2024; Maffezzoli et al., 2022; Raj & Prahadeeswaran, 2025). This new combination of machinery, data, and services open avenues for entirely new business models in platform-based ecosystems.

BUSINESS MODELS AS A MANAGEMENT CONCEPT

Business Model Architecture and Business Model Design

Technological innovation alone does not guarantee firm success (Teece, 2010). Instead, business models have emerged as a central concept in management research for explaining how firms structure activities and translating strategy into economic value. A substantial body of literature has examined the nature of business models, their core components, and the processes through which they are designed and innovated (Shamim et al., 2025).

Despite the absence of a universally accepted definition (Foss & Saebi, 2017; Laudien et al., 2024), a business model is commonly understood as describing how a firm creates value, delivers it to customers, and captures value through revenues and profits (Teece, 2010). These three dimensions constitute the value architecture of a business model and are interdependent, requiring simultaneous consideration in business model design and business model innovation (Spieth & Schneider, 2016).

Value creation refers to a firm's ability to develop offerings that customers perceive as valuable and is shaped by its resources, capabilities, and organizational arrangements, as well as by how effectively these elements are combined (Teece, 2010). Value delivery describes the mechanisms through which a firm transfers value created to customers and ensures that the value proposition is effectively realized in use. Value delivery encompasses the configuration of distribution channels, partnerships, customer relationships, and governance structures that enable a firm to reach target customers, provide access to its offerings, and support their use over time (Teece, 2010, 2018). Effective value delivery ensures that value creation is not only technically feasible but also accessible, scalable, and meaningful for customers, forming a critical link between innovation and value capture (Teece, 2010).

Value capture in business models refers to the mechanisms through which a firm appropriates value from its offerings, typically in the form of revenues and profits. Value capture depends on the alignment between the value proposition, cost structure, and revenue model, as well as on the firm's ability to appropriate returns from innovation (Teece, 2010, 2018). This involves decisions regarding pricing, revenue streams, intellectual property protection, and control over key complementary assets that limit imitation and profit erosion. Effective value capture is therefore contingent on

managerial choices that connect innovation to monetization and sustain competitive advantage over time (Chesbrough & Rosenbloom, 2002; Teece, 2010).

Taken together: a business model clarifies the benefit promised to customers, the operational system that enables its delivery, and the revenue logic that makes the enterprise viable. Yet, business models are dynamic systems of interdependent elements that must be aligned both internally and with the external environment (Baden-Fuller & Haefliger, 2013; Martins et al., 2015). Effective business models require strong internal coherence: the components must fit together and must be supported by appropriate organizational structures, managerial systems, and capabilities (Laudien & Pesch, 2019; Teece, 2018; Zott & Amit, 2008). When misalignment arises between a firm's value proposition and its ability to deliver on it, performance often suffers. This helps explain why incumbent firms frequently struggle to implement radical business model changes that demand substantial organizational and cultural adaptation.

The activity system view (Amit & Zott, 2001, 2010; Zott & Amit, 2007) conceptualizes business models as configurations of interdependent activities that transcend firm boundaries and collectively enable value creation and capture. Building on this perspective, a business model is an activity system that specifies the content, structure, and governance of activities performed by the firm and its partners (Zott & Amit, 2010). Content refers to which activities are performed, structure describes how these activities are linked and sequenced, and governance determines who performs them. This view emphasizes external alignment and how activities are designed, connected, and coordinated across a wider ecosystem. By focusing on activity interdependencies and design themes such as novelty, efficiency, complementarities, and lock-in, the activity system perspective provides a dynamic framework for analyzing business model innovation and strategic differentiation (Amit & Zott, 2001, 2010; Zott & Amit, 2007).

Business Model Innovation

Business model innovation enables disruption, fosters growth, and enhances long-term firm performance in dynamic environments (Cesinger et al., 2018; Kraus et al., 2022). In a general view, business model innovation refers to changes in the way firms structure, configure, and link activities to create, deliver, and capture value. Compared to product or process innovations, which target singular components of the value chain, business model innovation concerns changes across multiple, interdependent elements and the overarching logic of how a firm competes in the market (Amit & Zott, 2012; Demil & Lecocq, 2010). Modifications to one element then require corresponding adjustments to other elements to maintain coherence in business model architecture.

Differentiating between different types of business model innovation, Foss & Saebi (2017) define business model innovation as "designed, novel, and non-trivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (p. 216). According to Foss & Saebi (2017) business model innovation can be categorized into modular, architectural, radical, and incremental innovations. Modular business model innovation involves innovations within specific sources of value or single business model components, focusing on changes to discrete elements such as innovations in technology or modifications to revenue models. Architectural business model innovation, by contrast, emphasizes new ways of structuring, linking, or governing activities, as well as creating novel relationships among business model components. Radical and incremental business model innovation differ in terms of the extent of novelty they introduce on the firm and on the industry level.

Although business model innovation processes vary widely across firms and are shaped by firm-specific strategic choices and contextual conditions (Laudien & Daxböck, 2017), literature highlights that business model innovation processes unfold both within and across multiple organizational levels (Andreini et al., 2021) whereas experimentation and learning are essential in business model innovation (Andreini et al., 2021; Wirtz & Daiser, 2018), and where dynamics and power plays can occur among firms (Bouncken & Fredrich, 2016; Fredrich et al., 2022).

Servitization and Platformization of Business Models

"Servitization is [...] a transition, where the company moves from providing pure stand-alone products and add-on services to maintenance contracts, operational services and, finally, to outcome- or performance-based offerings (Kohtamäki et al., 2020, p. 3). Product firms may offer services to varying degrees, multiple services simultaneously, or at different levels in the value chain each of which require corresponding business model reconfigurations (Forkmann et al., 2017; Frank et al., 2019). Service-oriented digital business models operationalize this transition by bundling physical products with digital services, data analytics, maintenance, and performance-based offerings to create continuous revenue streams and enhance customer outcomes (Baines et al., 2009). The product-service system (PSS) embodies this transformation. The PSS is an integrated bundle of product–service solutions that emphasizes value-in-use and departs from traditional value creation logic. Connectivity, data analytics, and software enable firms to monitor product use, deliver outcome-oriented services, and scale advanced services at lower marginal costs, thereby reconfiguring customer relationships from one-time transactions to long-term service engagement and enabling new revenue models (Kohtamäki et al., 2020).

Platformization refers to the reorganization of economic activities, social relations, and governance structures around digital platforms that mediate interactions, orchestrate data flows, and shape value creation across multiple user groups (van Dijck et al., 2018). Within this context, research highlights the potential of digital platforms as vehicles for business model innovation, emphasizing that a central distinction in business model design concerns whether value creation is organized around a platform rather than a linear value chain (Täuscher & Laudien, 2018). Platforms often occupy a central position in digital ecosystems (Constantinides et al., 2018), consistent with the activity-system perspective on business models, which conceptualizes business models as systems of interdependent, boundary-spanning activities (Zott & Amit, 2008; Zott & Amit, 2010). While the platform concept itself is not new, digital technologies have substantially extended their scale and scope by enabling interoperability through shared standards allowing previously separate products or services to be recombined and opening the door to entirely new business models. Accordingly, a platform can be understood as a hardware–software foundation that defines the technical standards, interfaces, and rules enabling third-party providers to build complementary offerings.

Built on such core technological infrastructures, digital platforms function as intermediaries that connect internal and external actors, facilitating information exchange, product development, and the matching of supply and demand (Veile et al., 2022). Platform owners and complementors jointly form an ecosystem whose performance depends on ongoing platform development, coordination, and governance. While digital platforms are commonly categorized into two broad types, hybrid forms are common (Gawer & Cusumano, 2014). Innovation platforms – either across supply chains or across industry borders – supply a core technology and a distribution infrastructure that other firms can build upon, thereby increasing system-wide value. To thrive and gain the network effects, platform owners (such as OEMs) must attract complementors, whether these are firms or individual users (Reischauer et al., 2024). Both groups must perceive clear value in joining and contributing to the platform. Owners also need to decide whether participation should be exclusive, for instance, when content providers sign exclusive agreements with specific digital media services. In other situations, complementors may participate on multiple platforms simultaneously, depending on the incentives and restrictions created by the platform governance model.

Transaction platforms create value by facilitating exchanges of existing goods, services, or information among participant groups, such as buyers and sellers, service providers and users. The platforms' usefulness increases with participation, functionality, and content through network effects. Transaction platforms primarily capture value through transaction fees, advertising revenues, or both, and therefore depend on attracting participants who actively exchange goods, services, and data via the platform (Gawer, 2021).

Digital platforms provide firms with strategic opportunities by connecting diverse actors, streamlining coordination, and facilitating transactions, while generating network effects that enhance value creation and competitive advantage beyond what traditional business models allow. Once a platform establishes a substantial user base, users and developers alike prefer it because it offers richer interactions, more complementary products, and greater reach. Network effects constantly add value through the more users and solutions generated. Alternative platforms then struggle to attract the critical mass needed for survival. When firms operate in two-sided or multi-sided markets with sizable installed bases, competitive dynamics often shift toward winner-take-all or winner-take-most outcomes. Platform-based business models therefore face very different strategic pressures and opportunities than models that do not rely on such network effects to generate value (Teece, 2018).

Platform-based business models center on digital platforms that facilitate interactions among multiple user groups, such as producers, consumers, and service providers, enabling value creation through network effects. Rather than controlling linear value chains, platforms orchestrate ecosystems by providing standardized interfaces, data governance mechanisms, and algorithmic coordination (Gawer, 2014).

In Agriculture 4.0, platform-based business models revolve around digital platforms that coordinate OEMs, service providers, and farmers via standardized technical interfaces and shared data infrastructures, enabling algorithmic functions such as prescription generation, automated machine control, input optimization, and continuous performance monitoring.

BUSINESS MODEL TRANSFORMATION IN AGRICULTURE 4.0

Changes in OEMs' Value Creation, Value Delivery, and Value Capture in Agriculture 4.0

In the following, we provide a first overview of the overarching shift of OEM business models in agriculture. Contrasting pre-digital and digital-driven agricultural business models highlights a fundamental shift in how value creation, value delivery, and value capture.

Changes in OEMs' value creation

In conventional OEM models, value creation is primarily rooted in engineering and manufacturing excellence: firms compete through machine performance, durability, and incremental feature improvements, and customer value is largely assessed at the point of purchase. In Agriculture 4.0,

this logic is broadened and partially displaced by digitally enabled capabilities that translate field variability into actionable operational intelligence. Sensors, connectivity, and analytics turn machinery into data-generating assets, while AI-enabled functions, ranging from decision support to automated execution, allow performance to be improved, refined, and differentiated during use rather than solely through hardware specifications.

Value creation therefore becomes increasingly tied to an OEM's ability to combine physical equipment with software, data, and agronomic know-how into repeatable solutions that function across heterogeneous contexts. Competitive advantage shifts toward system design capabilities: integrating sensing, data processing, automation, and complementary services into coherent offerings that can be deployed reliably and adapted as conditions change. Mechanical quality remains a prerequisite, but it is no longer the primary locus of differentiation; what matters is the capacity to build a learning-oriented capability stack in which machines, data, and models continuously reinforce one another.

OEMs' value delivery in Agriculture 4.0

Historically, OEMs delivered value through discrete transactions and standardized service arrangements, with most customer interaction concentrated around purchasing, dealer-mediated support, and repair events. Agriculture 4.0 alters this delivery logic by extending the delivery process across the operational lifecycle of equipment. Connected machinery enables continuous customer engagement through configuration support, user enablement, diagnostics, software updates, performance monitoring, and the provision of digital features that can be activated, adjusted, or upgraded over time.

As a result, the OEM's delivery system increasingly depends on a coordinated service architecture that spans internal teams, dealers, digital platforms, and external complementors. The effectiveness of value delivery is shaped by the reliability of connectivity and the quality of integration across tools, brands, and data environments that farmers use in practice. Interoperability and workflow integration become delivery conditions rather than optional add-ons: if digital components do not connect smoothly, promised value remains latent. Consequently, service delivery in Agriculture 4.0 is less about responding to breakdowns and more about sustaining performance, usability, and fit-in-context across seasons through ongoing support and iterative refinement.

OEMs' value capture

Traditional OEM revenue logic is dominated by infrequent equipment purchases and a secondary stream of parts and repair services. Agriculture 4.0 enables a different monetization profile by creating revenue mechanisms that are linked to access, usage, and digitally enabled capabilities. Connectivity and software make it feasible to commercialize features in modular ways through subscriptions, licensing, pay-per-use arrangements, and service contracts that reflect realized benefits such as reduced inputs, improved timeliness, or higher operational efficiency.

This shifts value capture toward a portfolio of recurring income streams whose scale depends on installed-base engagement and the ability to keep digital services embedded in day-to-day operations. Because these mechanisms rely on persistent data flows and ongoing service provision, appropriation increasingly depends on controlling key complements: access rights, interfaces, data governance rules, and the ability to set the terms under which third-party services integrate with the OEM's infrastructure. Where such control is strong, OEMs can stabilize revenues, deepen customer relationships, and capture value beyond the initial sale. At the same time, this monetization shift raises strategic and governance questions about transparency, portability, and dependency, since the same mechanisms that support recurring revenues can also intensify lock-in concerns and shape bargaining positions in the ecosystem.

Agriculture 4.0 Business Models and the Activity System Perspective

The activity-system perspective conceptualizes business models as sets of interdependent activities whose value implications depend on their content, interdependencies, and governance across organizational boundaries (Amit & Zott, 2001, 2010; Zott & Amit, 2007). In Agriculture 4.0, business model transformation is thus not primarily driven by "adding digital features," but by reorganizing activities and their coordination in ways that alter how solutions are produced, delivered, and monetized (Bouncken et al., 2025).

Activity content expands beyond machinery design and manufacturing to include data-centric and software-centric activities such as sensing, integration, modeling, decision support, automation feature provisioning, and interoperability management. These activities are increasingly linked to operational use, such that improvement and differentiation depend on data accumulation and iterative refinement rather than solely on hardware replacement cycles. Moreover, the activity architecture becomes more interdependent across actors, requiring coordinated contributions by OEMs, dealers, platforms, agronomic experts, and complementors; value hinges on the alignment of interfaces, reliable data exchange, and clearly allocated service responsibilities. Finally, monetization becomes contingent on system participation: subscriptions, feature licensing, service contracts, and performance-linked arrangements are enabled by ongoing service provision and the governance of data and interfaces. Competitive advantage therefore increasingly depends on

how firms design and govern their activity systems, including rules for complementor participation and the distribution of control and accountability (Amit & Zott, 2001, 2010; Zott & Amit, 2007).

Servitized Activity Systems and Value Reconfiguration in Agriculture 4.0

Equipment-as-a-Service (EaaS) is a form of servitization in which manufacturers bundle hardware with complementary services and retain asset ownership (Benedettini, 2025). Customers pay for access, usage, or outcomes rather than for the product emphasizing long-term value delivery through integrated product–service solutions. Specific forms of EaaS are use- and result-oriented product–service systems, pay-per-use, or Product-/Everything-as-a-Service models (Benedettini, 2025). In agriculture, EaaS business models provision tractors or harvesters on subscription or pay-per-hour terms giving farmers access to high-end machinery without prohibitive capital expenditure. For seasonal machines such as combines or forage harvesters, this model significantly increases utilization rates while generating predictable recurring revenue for agritech OEMs (IMARC Group, 2025).

With pay-per-use services, "… product companies give customers access to products they desire. Instead of purchasing the products, companies allow customers to pay only for usage" (Gebauer et al., 2017, p. 916). Grimme, a major agricultural machinery manufacturer, offers pay-per-use options where farmers can book defined software-based functions and services for their machines through an online customer portal, called myGRIMME (GRIMME Skandinavien A/S, 2019). Farmers pay based on utilization instead of purchasing all functionality up front, effectively shifting Grimme's business model to a service-based revenue model tied to usage.

Subscription models are "… market offers where customers and providers mutually engage at various levels to provide access and usage or achieve outcomes in return for a periodically recurring fee" (Kowalkowski & Ulaga, 2024, p. 441). John Deere has layered subscriptions and usage-based licensing on its machine lineup: connectivity and telematics (JDLink / Operations Center) enable remote management, while certain advanced functions are sold as paid features or annual licenses (Operations Center Pro Service, See & Spray per-acre licensing). Commercially this works by bundling hardware with optional software features that can be unlocked and annual service fees (per-machine or per-acre), reducing upfront cost for farmers while creating predictable recurring revenue and a direct manufacturer–customer relationship for upgrades and support (Deere & Company, 2025a, b). AGCO's Fuse ecosystem and AGCO Connect (AGCO Corporation, 2019) show how a manufacturer can turn tractors, combines, and implements into data platforms. The company offers fleet telematics, dealer-assisted remote diagnostics, and subscription tiers for advanced analytics and management tools. The monetization levers include tiered software subscriptions, dealer integration fees, and value-added agronomy tools sold on top of the base connectivity. That converts occasional service touchpoints into ongoing digital engagements and enables dealer networks to sell recurring services.

Outcome-based models describe "… an agreement between the provider and the customer that the provider provides total solutions and is paid based on the outcomes of the solutions or the outcomes of customer value in a continual use situation" (Hou & Neely, 2018, p. 2103). Farmers pay a defined fee based on measurable results such as yield performance, harvested tonnage, or efficiency gains delivered by the equipment (Lončar et al., 2023). Blue River Technology's See & Spray, now integrated into John Deere's precision agriculture offerings, allows targeted herbicide application via AI vision. John Deere has introduced a pricing mechanism tied to performance/savings, called the Application Savings Guarantee. Under the Application Savings Guarantee, farmers pay a per-acre fee only when the technology delivers measurable savings in herbicide input. This aligns cost with value (i.e., what farmers actually save in inputs), and ties revenue to on-field outcomes rather than solely to a one-time purchase (Deere & Company, 2025a).

The emergence of Equipment-as-a-Service (EaaS), pay-per-use, subscription, and outcome-based models illustrates how Agriculture 4.0 reconfigures business models as interconnected activity systems in which value creation, delivery, and capture are tightly coupled. From a value-creation perspective, servitized models integrate physical machinery with software, connectivity, and analytics to generate operational capability rather than asset ownership. Value delivery in these models becomes episodic as well as continuous. Farmers benefit from flexibility to access services when needed and lower upfront costs. Service-based business models allow farmers incremental adoption (partial automation) rather than full replacement. At the same time, value is no longer just the machine; it is continuous and flexible access to optimized workflows, creating a mutually reinforcing ecosystem. Integrated subscriptions tie value to software familiarity, accumulated data, and coordinated workflows. Platforms and ecosystems demonstrate how manufacturers and dealer networks jointly deliver value through ongoing digital engagement, workflow integration, and service coordination (Bouncken & Kraus, 2022). These activity systems depend on interoperability between hardware, software, and organizational actors to sustain reliable performance in highly variable agricultural environments.

Value capture correspondingly shifts from episodic, capital-intensive transactions toward recurring and performance-linked revenue streams. Subscriptions, usage-based fees, and

outcome-based contracts align revenues with realized farm-level value while reducing farmers' upfront investment risk. By retaining asset ownership or control over critical digital capabilities, OEMs appropriate a larger share of lifecycle value and stabilize revenues across seasons.

Taken together, these servitized business models exemplify how Agriculture 4.0 transforms the business model activity system from a product-centric logic into a service- and outcome-oriented configuration in which value creation, delivery, and capture co-evolve around continuous use, data-driven optimization, and shared performance outcomes.

Platform-Based Business Models and the Reconfiguration of Value in Agriculture 4.0

FieldView is a digital agriculture platform by Bayer that collects, visualizes, and analyzes agronomic data from planting, fertilization, crop protection, and harvest to help farmers to make informed decisions and improve productivity. It integrates real time data from different machines and sources and offers tools such as satellite and yield maps as well as analytics to optimize crop production throughout the entire season (Bayer CropScience Schweiz AG, 2023).

Blue River Technology is a U.S. agricultural technology company and subsidy of John Deere that develops intelligent machinery using computer vision, ML, and robotics to help farmers manage crops more sustainably and efficiently. As part of John Deere's extensive precision-agriculture digital ecosystem, the See & Spray™ system is a networked, click-and-go solution designed to identify individual plants and apply chemicals only where needed, reducing herbicide use, improving yields, and optimizing field operations (Blue River Technology, 2025). At the same time, major technology firms are envisioning agriculture as a strategic expansion domain for their digital offerings. They increasingly provide cloud services, AI capabilities, and data-analytics solutions tailored to agricultural applications. These strategic moves not only extend their reach into the agricultural sector but also strengthen their control over foundational digital infrastructures, thereby intensifying platform-driven consolidation. For example, Amazon Web Services has introduced a digital marketplace through which analytics providers and software developers can distribute their solutions to a broader set of agricultural users (Expert AWS, 2023). Microsoft's Azure FarmBeats and Azure Data Manager for Agriculture provide a cloud-based platform that integrates IoT sensor data, satellites, drones, and analytics for farm decision support. Agripilot.ai, for example, deployed an AI-driven solution built on Microsoft's Azure FarmBeats (World Economic Forum, 2025). Google Cloud has collaborated with BASF to develop and deploy generative AI tools tailored to agricultural decision-making and farm management (BASF SE, 2024).

These examples demonstrate that Agriculture 4.0 fundamentally reconfigures business models by transforming how value is created, delivered, and captured within platform-based activity systems. Value emerges from coordinated configurations of digital technologies, data flows, and organizational activities that span multiple actors and lifecycle stages. Platforms integrate sensing, analytics, and automation into coherent activity systems that continuously generate agronomic insights and operational intelligence throughout the growing season.

From a value creation perspective, digital platforms enable the combination of heterogeneous data sources – machines, fields, weather, and inputs – into analytics and AI-driven applications that support precision decision-making and automated interventions. Platforms illustrate how value creation in Agriculture 4.0 is increasingly relational and systemic, depending on the integration of hardware, software, and data rather than on stand-alone technological components. Value delivery in platform-based business models is continuous and interactive. Connected machinery and cloud-based infrastructures extend engagement beyond the point of sale, embedding digital services into daily farm operations through real-time monitoring, analytics, and automation. The effectiveness of value delivery depends on interoperability, workflow integration, and the reliability of digital infrastructures that allow farmers to realize value in use. At the same time, the growing involvement of major technology firms highlights how value delivery increasingly relies on shared digital infrastructures that support scalability, modular innovation, and ecosystem coordination (He et al., 2024). Value capture is correspondingly reoriented from episodic equipment sales toward recurring, scalable revenue models tied to platform participation. Subscriptions, software licensing, data analytics, and performance-based services enable firms to appropriate value continuously across the agricultural lifecycle. As platforms accumulate data histories and embed themselves into farmers' operational routines, switching costs increase, reinforcing lock-in and stabilizing revenue streams. The entry of large technology providers further intensifies competition for value capture by consolidating control over foundational cloud and AI infrastructures, thereby reshaping power relations within agricultural ecosystems.

Taken together, these findings underscore that platform-based business models in Agriculture 4.0 function as complex activity systems in which value creation, delivery, and capture are tightly interdependent and distributed across ecosystems rather than confined to single firms. The strategic challenge for agritechs lies not only in developing advanced technologies, but in orchestrating activity systems that align digital infrastructures, agronomic expertise, and economic incentives. As Agriculture 4.0 continues to evolve, competitive advantage will increasingly depend on a firm's ability to design,

govern, and scale such platform-based activity systems while maintaining trust, interoperability, and contextual fit with farming practices.

Agriculture 4.0 Innovation Platforms as Complementors

Agritech start-ups contribute to this emerging landscape by developing novel tools and applications that plug into these platforms. Established corporations, including firms like Bayer (formerly Monsanto) and John Deere, have increasingly invested in such start-ups to secure access to emerging technologies and embed these innovations within their own operational and platform architectures (Bayer AG, 2023; Deere & Company, 2023).

Bayer's LifeHubs, for example, form a global open-innovation platform that supports agricultural transformation by providing startups with expertise, market insight, and incubator access to develop affordable, farmer-focused solutions (TechTour, 2025). LEAPS, the strategic investment unit of Bayer, supports early-stage ventures with breakthrough innovations in life sciences. Leaps' agricultural investments span technologies such as gene editing, sustainable crop platforms, carbon sequestration, microbial and biological solutions, and digital tools supporting precision and regenerative practices (Bayer AG, 2023).

John Deere partners with more than 200 companies through its Operations Center platform (Deere & Company, 2023). John Deere's Startup Collaborator Program was launched in 2019 to deepen collaboration with early-stage companies whose technologies could add value for agricultural customers. The program is part of Deere's broader push to explore new innovations that improve productivity, sustainability, and efficiency in farming. The 2025 Startup Cohort included, for example, Presien that develops on-machine AI solutions to improve safety and productivity or Landscan, which combines soil and remote sensing data into analytics to optimize land and resource management (Deere & Company, 2025a).

These innovation platforms function as critical complements to business models by acting as pipelines for future business model innovation in Agriculture 4.0. By enabling agritech start-ups to develop modular tools, applications, and services that plug into existing digital platforms, these innovation ecosystems expand the scope of experimentation beyond firm boundaries and accelerate the emergence of new value propositions. Incumbent agritechs such as Bayer and John Deere strategically invest in and collaborate with start-ups to access emerging technologies early and embed them within their operational and platform architectures, thereby shaping the trajectory of future offerings. Initiatives such as Bayer's LifeHubs and LEAPS, and John Deere's Operations Center and Startup Collaborator Program, illustrate how innovation platforms support exploratory innovation in areas ranging from digital decision support and AI-enabled machinery to biological solutions and regenerative practices, while simultaneously reinforcing incumbents' platform-based business models. As such, innovation platforms do not merely supplement existing business models but systematically feed the development of next-generation service, platform, and ecosystem configurations that will define competitive advantage in Agriculture 4.0.

Agriculture 4.0 as Modular, Architectural, or Radical Business Model Innovation

Business model transformation in Agriculture 4.0 can be systematically interpreted through the typology of business model innovation proposed by Foss & Saebi (2017). Many changes reflect modular business model innovation, such as the introduction of data-based revenue models (e.g., subscriptions or outcome-based contracts), the expansion of organizational boundaries through digital partnerships, and the integration of AI-driven analytics into existing value propositions. At the same time, Agriculture 4.0 increasingly exhibits architectural business model innovation, as firms reorganize and govern interdependent activities across connected machinery, digital platforms, and ecosystem partners, fundamentally altering how value is created and delivered. In several cases, these architectural changes approach radical business model innovation, particularly where agritechs shift from equipment sales to platform-centered, performance-oriented models that redefine industry roles and revenue logic. Incremental innovations coexist with these shifts, for instance through gradual enhancements of digital services layered onto established products. Together, Agriculture 4.0 illustrates how modular and architectural innovations interact, with cumulative changes reshaping both firm-level business models and the broader agricultural ecosystem.

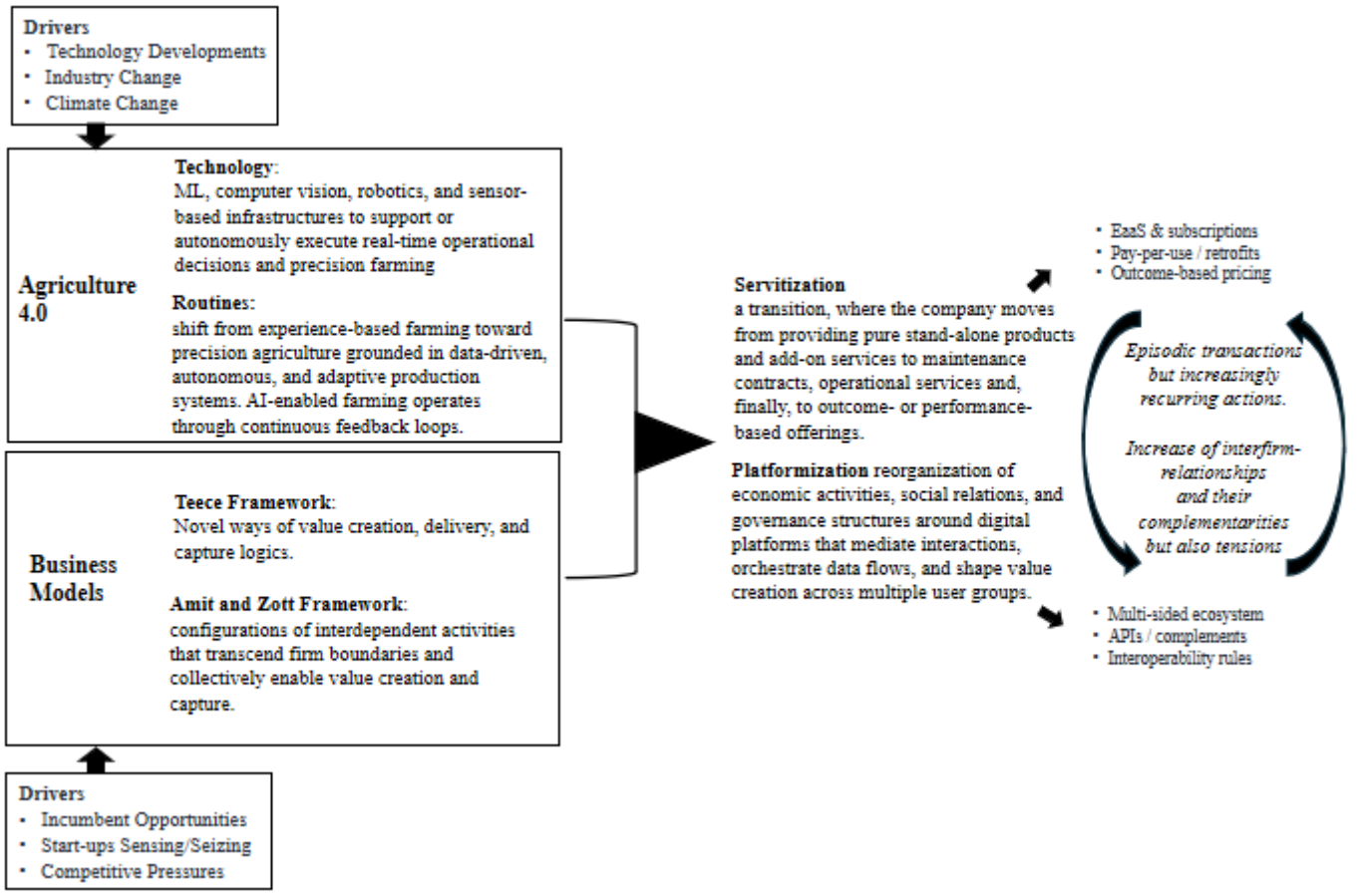
Viewed through the lens of Foss and Saebi (2017), innovation platforms in Agriculture 4.0 primarily function as mechanisms of architectural business model innovation, while simultaneously enabling modular and, in some cases, radical change. At a modular level, platforms such as Bayer's LifeHubs or John Deere's Startup Collaborator Program allow start-ups to contribute discrete technologies, applications, and services that enhance specific business model components without immediately altering the overall architecture. Innovation platforms act as architectural anchors that systematically channel modular experimentation into broader, potentially radical business model transformation in Agriculture 4.0.

DISCUSSION

Agriculture 4.0 when seen in a business model innovation light, here with focus on two conceptualization of business model, lead to two main changes which are servitization

and platformization. Before we explain more details, Figure 1 delivers an overview how Agriculture 4.0, driven by technology developments, industry and climate change, and by incumbent opportunities and competitive pressures, reconfigures farming routines toward data-driven, autonomous, feedback-looped production. Building on the business model lenses, the shift triggers servitization and platformization, moving from episodic product transactions to recurring, usage-based and outcome-based value capture (e.g., FaaS/subscriptions, pay-per-use/retrofits) and multi-sided ecosystems governed through APIs and interoperability rules. As a consequence, interfirm relationships and complementarities expand, often accompanied by new tensions.

Figure



Integrated Platforms as Drivers of Business Model Innovation in Agriculture 4.0

Building on Teece's (2010) business model framework, the transformation of incumbent agritechs such as John Deere can be understood as a systemic reconfiguration of how value is created, delivered, and captured within the emerging smart farming and Agriculture 4.0 landscape. Digitalization provides technological conditions for service- and platform-based business models, enabling more continuous, scalable, and resilient revenue streams that are less dependent on cyclical equipment sales. Rather than merely responding to farmer demand for integrated solutions, incumbent agritechs are actively restructuring their business models to orchestrate digital-mechanical service ecosystems that integrate connected machinery, agronomic data, analytics, and complementary services.

In this ecosystemic logic, value creation extends beyond producing hardware to generating intelligence through sensing, data analytics, automation, and interoperability, embedded in iterative workflows and cross-season learning loops. Value delivery becomes continuous and relational, relying on remote diagnostics, software updates, workflow integration, and dealer-mediated service coordination to embed benefits into everyday farm operations. Value capture shifts from episodic sales to recurring, outcome-linked streams, including subscriptions, pay-per-use fees, and performance-based contracts, aligning revenues with realized farm-level outcomes while reducing farmers' upfront investment risk.

Platform-based and service-based architectures further enable scalable monetization, increase switching costs, and reinforce lock-in by connecting hardware, software, services, and accumulated data into integrated ecosystems. Innovation platforms complement these business models by serving as pipelines for ongoing business model experimentation. By integrating start-up technologies into incumbent platforms,

innovation platforms expand the scope of innovation, accelerate the emergence of new services, and embed exploratory technologies within operational and platform architectures. These platforms thus not only support service- and data-driven business models but actively shape the evolution of next-generation ecosystem configurations that define competitive advantage in Agriculture 4.0.

Agriculture 4.0 reflects a layered transformation consistent with the typology of Foss & Saebi (2017). Incremental and modular innovations, such as data-based revenue models, AI-enabled services, and digital partnerships, modify individual business model components, while more profound architectural innovations restructure how activities are linked and governed across connected machinery, platforms, and ecosystem actors. In some cases, these architectural shifts approach radical business model innovation, as agritechs move from equipment-centric sales toward platform-based, performance-oriented models that redefine industry roles and value capture. Innovation platforms play a central role in this process by serving as architectural anchors: they enable modular experimentation by start-ups while channeling these innovations into broader ecosystem reconfigurations, thereby accelerating cumulative business model transformation in Agriculture 4.0.

Servitization, platformization, and Agriculture 4.0 are thus not isolated phenomena but interrelated business model innovations shaping the transition toward digitally enabled, outcome-oriented agricultural production systems. Firms that realign their business model components around these integrated, platform-based activity systems strengthen their strategic position, while those relying solely on hardware risk losing ground to actors that capture value through software, data, and orchestration capabilities.

Platformization: Blessing and Curse

Platforms function as the structural backbone of Agriculture 4.0 business models, orchestrating hardware, software, and complementary services while linking multiple actors – farmers, dealers, software providers, and start-ups – into cohesive activity systems that facilitate coordinated value creation, delivery, and capture. Platforms propel a broader platformization of agriculture which presents both significant opportunities and complex challenges.

Digital platforms integrate machinery, sensors, analytics, and services, enabling firms to coordinate operations across farms, suppliers, and service-provider networks more effectively. This integration supports value creation through continuous data-driven insights, predictive decision-making, and adaptive automation, shifting the unit of value from discrete machinery or input products to integrated systems, services, and intelligence. In activity-system terms (Zott & Amit, 2010), platforms expand both the content and structure of core business activities: value creation now includes sensor deployment, data acquisition, telematics, AI-driven agronomic analysis, and algorithmic optimization, while value delivery involves continuous lifecycle services, workflow integration, remote monitoring, and iterative feedback loops. Correspondingly, value capture moves toward subscriptions, pay-per-use, and outcome-oriented arrangements, transforming revenue models from episodic hardware sales into recurring, data-enabled streams.

Servitization, enabled by platforms, is central to this transformation. OEMs convert traditional product offerings into service-rich, platform-mediated solutions that bundle machinery with telematics, software functionalities, analytics, and predictive support. By embedding services within platforms, these firms extend engagement beyond the point of sale, delivering continuous value in use, enhancing operational efficiency, and enabling performance-linked pricing, such as pay-per-acre or outcome-based contracts.

From the farmer's perspective, digital platforms and data-driven service bundles in Agriculture 4.0 offer substantial benefits but also introduce new risks. On the benefit side, platforms lower transaction costs, facilitate third-party innovation, and provide access to advanced digital capabilities without large upfront investments. Service- and data-based models reduce entry barriers for small and resource-constrained farms by enabling pay-per-use, retrofits, or partial automation instead of costly machinery purchases, while large-scale farms benefit from flexible capacity scaling during peak seasons. Automation helps address persistent labor shortages and reduces physical work intensity, and data-driven insights improve precision, timeliness, and adaptability in input use, crop management, and risk mitigation (Klerkx et al., 2019). Interoperable platforms enhance analytical precision through network effects and allow farmers to combine equipment across brands, while gains in resource efficiency contribute to environmental benefits, including reduced emissions and ecological footprints (Finger, 2023; Macpherson et al., 2022; Rose et al., 2021).

At the same time, these benefits are accompanied by structural risks. Digital tools embed farmers in dense ecosystems of technological and organizational interdependencies, reducing unilateral decision-making and shifting adoption dynamics toward ecosystem-level configurations of capabilities, rules, and power relations (Van Der Burg et al., 2019). Farmers increasingly move from autonomous producers to users and data contributors within proprietary platforms, raising concerns about dependency, data ownership, bargaining power, and governance. AI-driven decision-making further alters human-technology relationships, positioning farmers as supervisors of algorithmic systems rather than sole decision-makers, which heightens issues of trust, accountability, and transparency and underscores the relevance of explainable

AI in agriculture (Barredo Arrieta et al., 2020).

From the start-up perspective, digital platforms in Agriculture 4.0 provide substantial opportunities to innovate, scale, and access markets that would otherwise be difficult to reach. Platforms lower market entry barriers by granting start-ups access to large customer bases, sophisticated infrastructure, and rich data networks, enabling the rapid deployment of innovations in sensing, analytics, automation, and decision support without the need to develop complete end-to-end solutions independently (Minerbo et al., 2021). Integration into established ecosystems accelerates customer acquisition, reduces infrastructure and operational costs, and enhances credibility through alignment with dominant machinery or farm management platforms, allowing start-ups to benefit from existing trust and adoption patterns. Participation in these ecosystems allows start-ups to experiment with complementary offerings that plug into larger platform architectures, effectively leveraging the platform as a springboard for broader business model innovation.

At the same time, platform participation introduces significant structural constraints and dependencies. Incumbent agritechs and platform owners typically hold substantial power through control of standards, interfaces, pricing, data access, and user relationships. This centralization of control can limit start-ups' strategic autonomy, constraining their ability to independently shape value propositions or capture the full benefits of their innovations (Minerbo et al., 2021). Competitive pressures are shifted inward: start-ups must differentiate themselves within ecosystems governed by incumbents and navigate the risk that successful innovations may be imitated, absorbed, or co-opted by dominant actors.

These dynamics produce a dual-edged environment for start-ups. On one hand, platforms enable experimentation, rapid iteration, and access to markets and resources that would be prohibitively costly to develop independently. On the other hand, they embed start-ups within hierarchical ecosystem structures where bargaining power is uneven, strategic choices are constrained, and dependency on platform owners can influence the long-term viability of the start-up's business model. Understanding this balance is critical: the success of start-ups in Agriculture 4.0 depends not only on technological innovation but also on their ability to navigate ecosystem governance, strategically align with dominant actors, and leverage platform participation without losing control over key value-creating activities.

Platform Economics and Platform Governance

From the perspective of platform economics, agricultural platforms operate as multi-sided markets characterized by strong network effects, economies of scale, and centralized governance over standards and interfaces (Rochet & Tirole, 2003). Platforms enhance analytical precision, enabling increasingly granular decision-support services for farmers and service providers while reinforcing existing power asymmetries. Farmers and smaller providers become dependent on platform owners for access to data, technological compatibility, and market visibility. Control over standards and infrastructures grants platform owners significant infrastructural power to shape not only technical conditions but also economic relationships and strategic choices (Plantin et al., 2018). Consequently, farmers' autonomy may erode and their bargaining positions weaken, particularly where platform governance privileges the interests of large agribusinesses and technology firms (Bronson & Knezevic, 2016; Carolan, 2017). As more users, service providers, and data sources join, platform value grows, reinforcing lock-in effects. Interoperability initiatives allow farmers to operate machinery across brands while accessing shared data services, expanding platform reach and analytical integration. Yet these arrangements also concentrate data and decision-making capabilities within a small number of dominant platforms, which increasingly define the rules of engagement and the distribution of value across agricultural ecosystems.

The dual role of platforms, as both enablers and gatekeepers, raises critical questions of ecosystem governance. Platform owners occupy structurally advantaged positions, controlling essential digital infrastructure, data flows, and access rules (Carbonell, 2016; Wiseman et al., 2019). This concentration of control can reinforce power asymmetries, reduce interoperability, and constrain farmer autonomy, thereby limiting the strategic and operational flexibility of dependent actors. For start-ups and smaller service providers, participation in incumbent-led platforms accelerates market access and adoption but also imposes dependence on platform governance, pricing mechanisms, and visibility algorithms. As a result, effective ecosystem orchestration becomes a central managerial challenge: creating, delivering, and capturing value increasingly relies not only on technological capabilities but also on governance structures, interface management, data stewardship, and mechanisms that ensure equitable participation across ecosystem actors (Klerkx & Begemann, 2020; Yoo et al., 2010).

Platformization in Agriculture 4.0 reflects a critical tension between openness and control. Open, interoperable platforms promote experimentation, third-party innovation, and collaborative problem-solving, lowering adoption barriers and enabling farmers, start-ups, and other actors to co-create value (Minerbo et al., 2021). Open standards and cross-brand interoperability allow farmers to choose solutions that fit their operational needs, integrate diverse tools and data sources, and reduce lock-in. In contrast, controlled or closed ecosystems enable platform owners and dominant agritech firms to protect proprietary algorithms, enforce quality standards, capture a larger share of revenue, and maintain

competitive advantage (Cusumano et al., 2019). However, excessive control can limit choice, constrain innovation, reinforce power asymmetries, and weaken farmers' long-term bargaining positions. Algorithmic filtering and proprietary data governance can lock users into specific ecosystems, potentially undermining adaptive, context-specific decision-making and limiting cross-platform analysis (Tian et al., 2021). Yet, algorithmic filtering in smart farming also enhances efficiency by sifting through large volumes of sensor and equipment data to identify critical anomalies, maintenance needs, and priority tasks. By highlighting actionable insights and automating recommendations, these systems support real-time adjustments in operations, optimize resource use, and improve productivity, operational efficiency, and overall farm management.

Innovation platforms can enable value co-creation by integrating scientific, technological, and local knowledge into embedded AI systems, but they also structure participation through platform-specific rules, languages, and competencies. This tension reflects the openness–control dilemma: while openness through interoperability and shared data access broadens participation and enhances co-creation, platform owners retain control via proprietary standards, governance mechanisms, and required competencies such as AI literacy. When participation is conditioned on technical fluency or compliance with platform logics, co-creation risks reinforcing power asymmetries, shifting platforms from inclusive spaces of joint value creation to mechanisms of selective value capture. This openness–control dilemma requires careful design of business model activity systems and governance mechanisms. Firms must balance flexibility, scalability, and appropriability to sustain competitive advantage while supporting adoption, innovation, and value co-creation across heterogeneous ecosystem actors. Ultimately, the equilibrium between openness and control is shaped by governance choices, standards, and institutional pressures, determining how benefits and risks are distributed within the agricultural digital ecosystem.

LIMITATIONS AND FUTURE RESEARCH

While this study provides a systemic perspective on Agriculture 4.0, platformization, and business model transformation, several limitations should be acknowledged. First, the analysis is primarily conceptual, synthesizing insights from literature on smart farming, platforms, and business model innovation. Empirical validation across diverse agricultural contexts is necessary to test and refine the theoretical propositions, particularly regarding how modular, architectural, and radical business model innovations unfold in practice and interact with ecosystem governance structures.

Second, the discussion emphasizes farmers, start-ups, and incumbents in North American and European contexts, reflecting the focus of current literature. Future research should examine adoption dynamics, platform governance, and business model evolution in emerging markets, where resource constraints, institutional environments, and digital infrastructure differ substantially, potentially altering value creation and appropriation patterns.

Third, the study highlights the dual nature of platforms as enablers and gatekeepers, emphasizing power asymmetries, dependencies, and the openness–control dilemma. However, the analysis does not systematically measure the magnitude or outcomes of these effects at the actor level. Future research could adopt micro-foundations approaches, combining surveys, case studies, and platform usage analytics to examine how individual and organizational capabilities, decision-making processes, trust, and human–algorithm interactions mediate the effects of governance structures, algorithmic filtering, and interoperability. Such work could quantify how these dynamics shape farmer autonomy, start-up innovation, and ecosystem-level performance, providing insights into how platform-level design choices translate into on-the-ground behavioral and economic outcomes. Future research may also examine how different platform governance configurations balance openness and control, and how these choices shape who can participate in AI-enabled co-creation across heterogeneous user groups. In particular, longitudinal and comparative studies could investigate how platform rules, interoperability standards, and required competencies such as AI literacy influence power asymmetries, inclusion, and the distribution of value in Agriculture 4.0 innovation ecosystems. Finally, while the paper considers technological enablers such as AI, robotics, and data analytics, it treats socio-technical interactions largely at a conceptual level. Future research could investigate how human-machine relationships, trust in algorithmic decision-making, and explainable AI affect adoption, risk perception, and farm-level outcomes. Similarly, the role of tacit knowledge, local practices, and context-specific adaptations in shaping digitalization outcomes warrants deeper exploration.

Addressing these limitations offers a rich agenda for research, combining multi-level, cross-context analyses to better understand how digital platforms, business models, and ecosystem governance jointly shape the transformative potential, risks, and equitable outcomes of Agriculture 4.0.

Conclusion

Agriculture 4.0 represents a systemic transformation in which digital technologies, platforms, and data-driven services reshape business models, value creation, and governance across the agri-food ecosystem. Firms are moving beyond product-centric approaches toward service-oriented and

platform-mediated models, combining modular innovations with architectural innovations that restructure activities, interdependencies, and ecosystem relationships. Innovation platforms function as catalysts, channeling experimentation by start-ups into broader architectural change, and enabling new configurations of value capture and delivery.

Taken together, Agriculture 4.0 illustrates that digitalization is not merely a technological evolution but a reconfiguration of activity systems, inter-organizational networks, and value governance. Sustainable advantages emerge not from technology alone but from orchestrating activity systems that integrate physical, digital, and organizational resources while balancing openness, control, and equitable participation. Understanding this duality is critical for theory, practice, and policy, offering a lens to assess both the transformative potential and socio-economic tensions inherent in the platform-mediated digitalization of agriculture.

REFERENCES

1. AGCO Corporation. 2019. Subscriptions: Subscription plan and period information, and renewal and cancellation options. https://get.agcoconnect.com/support/subscriptions/

2. Ahmed, N., & Shakoor, N. 2025. Advancing agriculture through IoT, Big Data, and AI: A review of smart technologies enabling sustainability. Smart Agricultural Technology, 10: 100848. doi:10.1016/j.atech.2025.100848.

3. Amit, R., & Zott, C. 2001. Value creation in e-business. Strategic Management Journal, 22(6–7): 493–520. doi:10.1002/smj.187.

4. Amit, R., & Zott, C. 2010. Business model innovation: Creating value in times of change. Unpublished Working Paper WP-870, IESE Business School, University of Navarra, Barcelona

5. Amit, R., & Zott, C. 2012. Creating value through business model innovation. MIT Sloan Management Review, 53(3): 41–49

6. Andreini, D., Bettinelli, C., Foss, N. J., & Mismetti, M. 2021. Business model innovation: a review of the process-based literature. Journal of Management and Governance, 26(4): 1089-1121. doi:10.1007/s10997-021-09590-w.

7. Assimakopoulos, F., Vassilakis, C., Margaris, D., Kotis, K., & Spiliotopoulos, D. 2024. Artificial Intelligence Tools for the Agriculture Value Chain: Status and Prospects. Electronics, 13(22): 4362. doi:10.3390/electronics13224362.

8. Baden-Fuller, C., & Haefliger, S. 2013. Business models and technological innovation. Long Range Planning, 46(6): 419-426. doi:10.1016/j.lrp.2013.08.023.

9. Bahoo, S., Cucculelli, M., & Qamar, D. 2023. Artificial intelligence and corporate innovation: A review and research agenda. Technological Forecasting and Social Change, 188: 122264. doi:10.1016/j.techfore.2022.122264.

10. Baines, T. S., Lightfoot, H. W., Benedettini, O., & Kay, J. M. 2009. The servitization of manufacturing. Journal of Manufacturing Technology Management, 20(5): 547-567. doi:10.1108/17410380910960984.

11. Barredo Arrieta, A., Díaz-Rodríguez, N., Del Ser, J., Bennetot, A., Tabik, S., Barbado, A., Garcia, S., Gil-Lopez, S., Molina, D., Benjamins, R., Chatila, R., & Herrera, F. 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. Information Fusion, 58: 82-115. doi:10.1016/j.inffus.2019.12.012.

12. BASF SE. 2024. BASF collaborates with Google Cloud to launch Generative AI Chatbot Consultant Service for xarvio® FIELD MANAGER users in Japan, News Releases, Vol. 2025. https://www.basf.com/jp/en/media/news-releases/jp/2024/04/xarvio_gemini

13. Bayer AG. 2023. Leaps by Bayer. Breaking through impossible. https://leaps.bayer.com/approach

14. Bayer CropScience Schweiz AG. 2023. Wissen ist Ertrag. Sammle Daten, ergreife Massnahmen [Knowledge Is A Value. Collect Data, Take Action]. https://www.climatefieldview.de/

15. Bechar, A., & Vigneault, C. 2016. Agricultural robots for field operations: Concepts and components. Biosystems Engineering, 149: 94-111. doi:https://doi.org/10.1016/j.biosystemseng.2016.06.014.

16. Benedettini, O. 2025. Characterizing the trend towards Equipment-as-a-Service business models in B2B industries. Computers & Industrial Engineering, 201: 110815. doi:10.1016/j.cie.2024.110815.

17. Blue River Technology. 2025. Solving monumental

challenges for our customers. https://www.bluerivertechnology.com/

18. Bouncken, R., & Kraus, S. 2022. Entrepreneurial ecosystems in an interconnected world: Emergence, governance, and digitalization. Review of Managerial Science, 16: 1-14. doi:10.1007/s11846-021-00444-1.

19. Bouncken, R., Kraus, S., & Roig-Tierno, N. 2021. Knowledge- and innovation-based business models for future growth: Digitalized business models and portfolio considerations. Review of Managerial Science, 15(1): 1-14. doi:10.1007/s11846-019-00366-z.

20. Bouncken, R., & Schmitt, F. 2022. SME Family Firms and Strategic Digital Transformation: Inverting Dualisms Related to Overconfidence and Centralization. Journal of Small Business Strategy, 32(3): 1-17. doi:10.53703/001c.35278.

21. Bouncken, R. B., Covin, J. G., & Schmitt, F. 2025. Family firms' digital transformation: pathways and tensions. Small Business Economics. doi:10.1007/s11187-025-01146-8.

22. Bouncken, R. B., & Fredrich, V. 2016. Business model innovation in alliances: Successful configurations. Journal of Business Research, 69(9): 3584–3590. doi:10.1016/j.jbusres.2016.01.004.

23. Bronson, K., & Knezevic, I. 2016. Big Data in food and agriculture. Big Data & Society, 3(1): 205395171664817. doi:10.1177/2053951716648174.

24. Brousseau, E., & Penard, T. 2007. The economics of digital business models: a framework for analyzing the economics of platforms. Review of Network Economics, 6(2): 81-114. doi:10.2202/1446-9022.1112.

25. Carbonell, I. M. 2016. The ethics of big data in big agriculture. Internet Policy Review, 5(1). doi:10.14763/2016.1.405.

26. Carolan, M. 2017. Publicising Food: Big Data, Precision Agriculture, and Co-Experimental Techniques of Addition. Sociologia Ruralis, 57(2): 135-154. doi:https://doi.org/10.1111/soru.12120.

27. Cesinger, B., Gundolf, K., & Géraudel, M. 2018. Growth intention and sales revenue growth in small business: The mediating effect of firm size growth. International Journal of Technology Management, 78(3): 163-181. doi:10.1504/IJTM.2018.095628.

28. Chesbrough, H. W., & Rosenbloom, R. S. 2002. The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spin-off companies. Industrial and Corporate Change, 11(3): 529–555. doi:10.1093/icc/11.3.529.

29. Clauss, T., & Bouncken, R. B. 2019. Social power as an antecedence of governance in buyer-supplier alliances. Industrial Marketing Management, 77: 75–89. doi:10.1016/j.indmarman.2018.12.005.

30. Clauss, T., Bouncken, R. B., Laudien, S., & Kraus, S. 2020. Business model reconfiguration and innovation in SMEs: A mixed-method analysis from the electronics industry. International Journal of Innovation Management, 24(02): 2050015. doi:10.1142/S1363919620500152.

31. Constantinides, P., Henfridsson, O., & Parker, G. G. 2018. Introduction—Platforms and Infrastructures in the Digital Age. Information Systems Research, 29(2): 381-400. doi:10.1287/isre.2018.0794.

32. Cusumano, M. A., Gawer, A., & Yoffie, D. B. 2019. The Business of Platforms: Strategy in the Age of Digital Competition, Innovation, and Power: Harper Business

33. Deere & Company. 2023. Deere Company at a glance. https://www.deere.com/assets/pdfs/common/our-company/deere-&-company-at-a-glance.pdf

34. Deere & Company. 2025a. Digital Tools. https://www.deere.com/en/digital-tools/

35. Deere & Company. 2025b. Sprayers. https://www.deere.com/en/sprayers/

36. Demil, B., & Lecocq, X. 2010. Business model evolution: In search of dynamic consistency. Long Range Planning, 43(2-3): 227-246. doi:10.1016/j.lrp.2010.02.004.

37. Duguma, A. L., & Bai, X. 2024. How the internet of things technology improves agricultural efficiency. Artificial Intelligence Review, 58(2): 63. doi:10.1007/s10462-024-11046-0.

38. Finger, R. 2023. Digital innovations for sustainable and resilient agricultural systems. European Review of Agricultural Economics, 50(4): 1277-1309. doi:10.1093/erae/jbad021.

39. Forkmann, S., Ramos, C., Henneberg, S. C., & Naudé, P. 2017. Understanding the service infusion process as a business model reconfiguration. Industrial Marketing Management, 60: 151-166. doi:https://doi.org/10.1016/j.indmarman.2016.05.001.

40. Foss, N. J., & Saebi, T. 2017. Fifteen Years of Research on Business Model Innovation:How Far Have We Come, and Where Should We Go? Journal of Management, 43(1): 200-227. doi:10.1177/0149206316675927.

41. Frank, A. G., Mendes, G. H. S., Ayala, N. F., & Ghezzi, A. 2019. Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. Technological Forecasting and Social Change, 141: 341-351. doi:https://doi.org/10.1016/j.techfore.2019.01.014.

42. Fredrich, V., Bouncken, R., & Tiberius, V. 2022. Dyadic business model convergence or divergence in alliances? – A configurational approach. Journal of Business Research, 153: 300-308. doi:10.1016/j.jbusres.2022.08.046.

43. Gawer, A. 2014. Bridging differing perspectives on technological platforms: Toward an integrative framework. Research Policy, 43(7): 1239-1249. doi:10.1016/j.respol.2014.03.006.

44. Gawer, A. 2021. Digital platforms' boundaries: The interplay of firm scope, platform sides, and digital interfaces. Long Range Planning, 54(5): 102045. doi:10.1016/j.lrp.2020.102045.

45. Gawer, A., & Cusumano, M. A. 2014. Industry platforms and ecosystem innovation. Journal of Product Innovation Management, 31(3): 417-433. doi:10.1111/jpim.12105.

46. Gebauer, H., Haldimann, M., & Saul, C. J. 2017. Competing in business-to-business sectors through pay-per-use services. Journal of Service Management, 28(5): 914-935. doi:10.1108/JOSM-07-2016-0202.

47. GRIMME Skandinavien A/S. 2019. GRIMME Pay-Per-Use, News Archive, Vol. 2025. https://www.grimme.dk/en/news/news-archive/grimme-pay-per-use

48. He, K., Bouncken, R. B., Kiani, A., & Kraus, S. 2024. The role of strategic orientations for digital innovation: When entrepreneurship meets sustainability. Technological Forecasting and Social Change, 205: 123503. doi:10.1016/j.techfore.2024.123503.

49. Hou, J., & Neely, A. 2018. Investigating risks of outcome-based service contracts from a provider's perspective. International Journal of Production Research, 56(6): 2103-2115. doi:10.1080/00207543.2017.1319089.

50. IMARC Group. 2025. Agriculture Technology as a Service Market Size, Agriculture Technology as a Service Market Report by Service Type (Software-as-a-Service (SaaS), Equipment-as-a-Service (EaaS)), Technology (Guidance Technology, Data Analytics and Intelligence, Variable Rate Application Technology, Sensing Technology, and Others), Pricing (Pay-Per-Use, Subscription), Application (Yield Mapping and Monitoring, Soil Management and Testing, Crop Health Monitoring, Irrigation, and Others), and Region 2025-2033. https://www.imarcgroup.com/agriculture-technology-as-a-service-market

51. Javaid, M., Haleem, A., Singh, R. P., & Suman, R. 2022. Enhancing smart farming through the applications of Agriculture 4.0 technologies. International Journal of Intelligent Networks, 3: 150-164. doi:10.1016/j.ijin.2022.09.004.

52. Jordan, M. I., & Mitchell, T. M. 2015. Machine learning: Trends, perspectives, and prospects. Science, 349(6245): 255-260. doi:doi:10.1126/science.aaa8415.

53. Jorzik, P., Klein, S. P., Kanbach, D. K., & Kraus, S. 2024. AI-driven business model innovation: A systematic review and research agenda. Journal of Business Research, 182: 114764. doi:10.1016/j.jbusres.2024.114764.

54. Kanbach, D. K., Heiduk, L., Blueher, G., Schreiter, M., & Lahmann, A. 2024. The GenAI is out of the bottle: Generative artificial intelligence from a business model innovation perspective. Review of Managerial Science, 18(4): 1189-1220. doi:10.1007/s11846-023-00696-z.

55. Klerkx, L., & Begemann, S. 2020. Supporting food systems transformation: The what, why, who, where and how of mission-oriented agricultural innovation systems. Agricultural Systems, 184: 102901. doi:10.1016/j.agsy.2020.102901.

56. Klerkx, L., Jakku, E., & Labarthe, P. 2019. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. NJAS: Wageningen Journal of Life Sciences, 90-91(1): 1-16. doi:10.1016/j.njas.2019.100315.

57. Kohtamäki, M., Parida, V., Oghazi, P., Gebauer, H., & Baines, T. 2019. Digital servitization business

models in ecosystems: A theory of the firm. Journal of Business Research, 104: 380-392. doi:10.1016/j.jbusres.2019.06.027.

58. Kohtamäki, M., Parida, V., Patel, P. C., & Gebauer, H. 2020. The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization. Technological Forecasting and Social Change, 151: 119804. doi:https://doi.org/10.1016/j.techfore.2019.119804.

59. Kowalkowski, C., & Ulaga, W. 2024. Subscription offers in business-to-business markets: Conceptualization, taxonomy, and framework for growth. Industrial Marketing Management, 117: 440-456. doi:10.1016/j.indmarman.2024.01.014.

60. Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. 2022. Digital transformation in business and management research: An overview of the current status quo. International Journal of Information Management, 63: 102466. doi:10.1016/j.ijinfomgt.2021.102466.

61. Laudien, S. M., & Daxböck, B. 2017. Business model innovation processes of average market players: a qualitative-empirical analysis. R&D Management, 47(3): 420-430. doi:10.1111/radm.12208.

62. Laudien, S. M., & Pesch, R. 2019. Understanding the influence of digitalization on service firm business model design: a qualitative-empirical analysis. Review of Managerial Science, 13(3): 575-587. doi:10.1007/s11846-018-0320-1.

63. Laudien, S. M., Reuter, U., Sendra Garcia, F. J., & Botella-Carrubi, D. 2024. Digital advancement and its effect on business model design: Qualitative-empirical insights. Technological Forecasting and Social Change, 200: 123103. doi:https://doi.org/10.1016/j.techfore.2023.123103.

64. Lončar, M., Kresović, D., Bolbotinović, Ž., Radojičić, S., Krstić, A., & Vukmirović, J. 2023. Outcome Based Business Models Influenced with Internet of Things – in Agriculture. E-business technologies conference proceedings, 3(1): 152-158

65. Macpherson, J., Voglhuber-Slavinsky, A., Olbrisch, M., Schöbel, P., Dönitz, E., Mouratiadou, I., & Helming, K. 2022. Future agricultural systems and the role of digitalization for achieving sustainability goals. A review. Agronomy for Sustainable Development, 42(4). doi:10.1007/s13593-022-00792-6.

66. Maffezzoli, F., Ardolino, M., Bacchetti, A., Perona, M., & Renga, F. 2022. Agriculture 4.0: A systematic literature review on the paradigm, technologies and benefits. Futures, 142: 102998. doi:10.1016/j.futures.2022.102998.

67. Martins, L. L., Rindova, V. P., & Greenbaum, B. E. 2015. Unlocking the hidden value of concepts: A cognitive approach to business model innovation. Strategic Entrepreneurship Journal, 9(1): 99-117. doi:10.1002/sej.1191.

68. Minerbo, C., Kleinaltenkamp, M., & Ledur-Brito, L.-A. 2021. Unpacking value creation and capture in B2B relationships. Industrial Marketing Management, 92: 163-177

69. Padhiary, M., Kumar, A., & Sethi, L. N. 2025. Emerging technologies for smart and sustainable precision agriculture. Discover Robotics, 1(1): 6. doi:10.1007/s44430-025-00006-0.

70. Padhiary, M., Kumar, R., & Sethi, L. N. 2024. Navigating the future of agriculture: A comprehensive review of automatic all-terrain vehicles in precision farming. Journal of The Institution of Engineers (India): Series A, 105(3): 767-782. doi:10.1007/s40030-024-00816-2.

71. Plantin, J.-C., Lagoze, C., Edwards, P. N., & Sandvig, C. 2018. Infrastructure studies meet platform studies in the age of Google and Facebook. New Media & Society, 20(1): 293-310. doi:10.1177/1461444816661553.

72. Raj, M., & Prahadeeswaran, M. 2025. Revolutionizing agriculture: a review of smart farming technologies for a sustainable future. Discover Applied Sciences, 7(9): 937. doi:10.1007/s42452-025-07561-6.

73. Reischauer, G., Engelmann, A., Gawer, A., & Hoffmann, W. H. 2024. The slipstream strategy: How high-status OEMs coopete with platforms to maintain their digital extensions' edge. Research Policy, 53(7): 105032. doi:10.1016/j.respol.2024.105032.

74. Rochet, J.-C., & Tirole, J. 2003. Platform Competition in Two-sided Markets. Journal of the European Economic Association, 1(4): 990-1029

75. Rose, D. C., Wheeler, R., Winter, M., Lobley, M., & Chivers, C.-A. 2021. Agriculture 4.0: Making it work for people, production, and the planet. Land Use Policy, 100: 104933. doi:10.1016/j.landusepol.2020.104933.

76. Shamim, S., Acikgoz, F., Akhtar, P., Sarala, R., Zahoor, N., & Elwalda, A. 2025. Rapid innovation management capability, and crisis-driven business model innovation performance: Roles of strategic-IT-alignment, and operational-IT-effectiveness. Journal of Business Research, 193: 115358. doi:10.1016/j.jbusres.2025.115358.

77. Shamshiri, R. R. 2024. Electrical tractors for autonomous farming, Mobile Robots for Digital Farming: 89-106: CRC Press

78. Sharma, R., & Chandola, V. 2025. Agricultural Equipment Telematics Market Research Report 2033. In R. Phatak (Ed.): 251. Ontario, CA 91764, United States: DataIntelo Solutions LLP.

79. Şimşek, T., Öner, M. A., Kunday, Ö., & Olcay, G. A. 2022. A journey towards a digital platform business model: A case study in a global tech-company. Technological Forecasting and Social Change, 175: 121372. doi:https://doi.org/10.1016/j.techfore.2021.121372.

80. Spagnuolo, M., Todde, G., Caria, M., Furnitto, N., Schillaci, G., & Failla, S. 2025. Agricultural Robotics: A Technical Review Addressing Challenges in Sustainable Crop Production. Robotics, 14(2): 9. doi:10.3390/robotics14020009.

81. Spanaki, K., Karafili, E., & Despoudi, S. 2021. AI applications of data sharing in agriculture 4.0: A framework for role-based data access control. International Journal of Information Management, 59: 102350. doi:10.1016/j.ijinfomgt.2021.102350.

82. Spieth, P., & Schneider, S. 2016. Business model innovativeness: designing a formative measure for business model innovation. Journal of Business Economics, 86(6): 671-696. doi:10.1007/s11573-015-0794-0.

83. Storm, H., Seidel, S. J., Klingbeil, L., Ewert, F., Vereecken, H., Amelung, W., Behnke, S., Bennewitz, M., Börner, J., Döring, T., Gall, J., Mahlein, A.-K., McCool, C., Rascher, U., Wrobel, S., Schnepf, A., Stachniss, C., & Kuhlmann, H. 2024. Research priorities to leverage smart digital technologies for sustainable crop production. European Journal of Agronomy, 156: 127178. doi:10.1016/j.eja.2024.127178.

84. Täuscher, K., & Laudien, S. M. 2018. Understanding platform business models: A mixed methods study of marketplaces. European Management Journal, 36(3): 319-329. doi:10.1016/j.emj.2017.06.005.

85. TechTour. 2025. Transforming Agriculture: Bayer's Karl D. Collins on Innovation, Ecosystems & Europe's Resilient Ag Breakthrough. https://techtour.com/news-transforming-agriculture-bayers-karl-d-collins-on-innovation-ecosystems-europes-resilient-ag-breakthrough/

86. Teece, D. J. 2010. Business models, business strategy and innovation. Long Range Planning, 43(2-3): 172-194. doi:10.1016/j.lrp.2009.07.003.

87. Teece, D. J. 2018. Business models and dynamic capabilities. Long Range Planning, 51(1): 40-49. doi:10.1016/j.lrp.2017.06.007.

88. Tian, J., Vanderstraeten, J., Matthyssens, P., & Shen, L. 2021. Developing and leveraging platforms in a traditional industry: An orchestration and co-creation perspective. Industrial Marketing Management, 92: 14-33. doi:10.1016/j.indmarman.2020.10.007.

89. Uyar, H., Karvelas, I., Rizou, S., & Fountas, S. 2024. Data value creation in agriculture: A review. Computers and Electronics in Agriculture, 227: 109602. doi:https://doi.org/10.1016/j.compag.2024.109602.

90. Van Der Burg, S., Bogaardt, M.-J., & Wolfert, S. 2019. Ethics of smart farming: Current questions and directions for responsible innovation towards the future. NJAS: Wageningen Journal of Life Sciences, 90-91(1): 1-10. doi:10.1016/j.njas.2019.01.001.

91. van Dijck, J., Poell, T., & de Waal, M. 2018. The Platform Society: Oxford University Press. doi:10.1093/oso/9780190889760.001.0001.

92. Vargo, S. L., & Lusch, R. F. 2007. Service-dominant logic: continuing the evolution. Journal of the Academy of Marketing Science, 36(1): 1-10. doi:10.1007/s11747-007-0069-6.

93. Veile, J. W., Schmidt, M.-C., & Voigt, K.-I. 2022. Toward a new era of cooperation: How industrial digital platforms transform business models in Industry 4.0. Journal

of Business Research, 143: 387-405. doi:10.1016/j.jbusres.2021.11.062.

94. Wirtz, B., & Daiser, P. 2018. Business Model Innovation Processes: A Systematic Literature Review. Journal of Business Models, 6 (1): 40-58. doi:https://doi.org/10.5278/ojs.jbm.v6i1.2397.

95. Wiseman, L., Sanderson, J., Zhang, A., & Jakku, E. 2019. Farmers and their data: An examination of farmers' reluctance to share their data through the lens of the laws impacting smart farming. NJAS: Wageningen Journal of Life Sciences, 90-91(1): 1-10. doi:10.1016/j.njas.2019.04.007.

96. Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. 2017. Big Data in Smart Farming – A review. Agricultural Systems, 153: 69-80. doi:https://doi.org/10.1016/j.agsy.2017.01.023.

97. World Economic Forum. 2025. Shaping the Deep-Tech Revolution in Agriculture. Cologny/Geneva: World Economic Forum

98. Yoo, Y., Henfridsson, O., & Lyytinen, K. 2010. Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. Information Systems Research, 21(4): 724-735. doi:10.1287/isre.1100.0322.

99. Zhu, H., Lin, C., Liu, G., Wang, D., Qin, S., Li, A., Xu, J.-L., & He, Y. 2024. Intelligent agriculture: Deep learning in UAV-based remote sensing imagery for crop diseases and pests detection. Frontiers in Plant Science, 15: 1435016. doi:10.3389/fpls.2024.1435016.

100. Zott, C., & Amit, R. 2007. Business model design and the performance of entrepreneurial firms. Organization Science, 18(2): 181–199. doi:10.1287/orsc.1060.0232.

101. Zott, C., & Amit, R. 2008. The fit between product market strategy and business model: Implications for firm performance. Strategic Management Journal, 29(1): 1–26. doi:10.1002/smj.642.

102. Zott, C., & Amit, R. 2010. Business model design: An activity system perspective. Long Range Planning, 43(2): 216–226. doi:10.1016/j.lrp.2009.07.004.