

DIGITAL TRANSFORMATION IN FARMER-TO-CONSUMER VEGETABLE MARKETING: OPPORTUNITIES AND BARRIERS

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Abstract

The agricultural sector has been undergoing substantial changes due to advances in digital technologies, and these shifts are increasingly influencing how vegetables are marketed directly from farmers to consumers. Digital transformation includes the use of technology such as the Internet of Things (IoT), blockchain, artificial intelligence (AI), mobile applications, and e-marketplaces. These technologies present significant prospects to improve the efficiency, transparency, and sustainability of vegetable supply chains.

INTRODUCTION

Traditional vegetable marketing techniques frequently include many intermediaries, resulting in inefficiencies, increased expenses, and lower profit margins for farmers. These approaches may also result in lengthier supply chains, increasing the likelihood of food spoilage and waste. In contrast, digital marketing solutions allow for direct connections between farmers and consumers, decreasing the need for intermediaries, improving logistics, and ensuring that fresher fruit reaches the market. The COVID-19 epidemic has pushed the

deployment of digital technology in agriculture, emphasizing their vital role in supply chain resilience during disturbances (Frontiers, SpringerLink).

SIGNIFICANCE OF STUDY

The transition to digital marketing in the agricultural sector is crucial for various reasons:

Economic Benefits: Direct-to-consumer digital platforms can help farmers earn more

money by lowering intermediary expenses and allowing for better price realization. This can be especially advantageous for small-scale farmers, who frequently face major barriers to accessing traditional markets.

Efficiency and traceability: Digital solutions such as IoT and blockchain increase supply chain transparency and efficiency by giving real-time data on manufacturing, storage, and transit. This can assist to reduce food loss and waste, improve quality control, and increase consumer trust.

Sustainability: Digital technology help to make agricultural methods more sustainable by optimizing resource utilization and reducing waste. Precision farming can improve output and reduce environmental impact

customer involvement: Digital platforms improve customer involvement through tailored marketing and direct feedback systems. Traceability data allows consumers to make more educated decisions, and they are often prepared to pay a premium for high-quality, traceable products.

However, the report recognizes considerable impediments to digital transformation, such as technological, financial, regulatory, and socio-cultural issues. Addressing these

impediments requires a multifaceted approach that includes government support, strategic investments, and farmer capacity-building efforts.

LITERATURE REVIEW

Drechsler and Holzapfel's 2022, this paper delves into the intricacies of digital transformation in fruit and vegetable supply chains through Interpretive Structural Modeling (ISM) and MICMAC analysis. The objective of the study is to identify and rank the obstacles that hinder the use of digital technologies in these supply chains, offering a systematic framework for comprehending their interconnections. The authors emphasize notable obstacles such as insufficient technological capabilities, substantial expenses of implementation, and the absence of digital literacy among farmers.

The ISM technique facilitates the identification of the connections between these obstacles, providing a graphical depiction of their hierarchical arrangement. The MICMAC analysis separates barriers into four clusters: autonomous, dependent, linking, and independent barriers, depending on their driving and reliance power. This dual-method approach allows for a thorough comprehension of both the direct and indirect

factors that impact the process of digital transformation.

An important finding of the study is the recognition of significant obstacles, such as inadequate infrastructure and budgetary limitations, which have a strong influence but are not heavily influenced by other factors. These barriers play a crucial role in the transformation process and must be addressed promptly to achieve successful digital adoption. On the other hand, impediments that have a strong reliance but a weak influence, such as resistance to change and regulatory challenges, are identified as areas that require supporting policies and involvement of stakeholders.

Kumar et al. 2021, the researcher provide a thorough and up-to-date analysis of the digital revolution in the agri-food industry, particularly highlighting the increased speed caused by the COVID-19 pandemic. The article examines the implementation of Industry 4.0 technologies, including IoT, AI, big data, and blockchain, and how they might be used to enhance agricultural practices and food supply chains.

The authors contend that the pandemic has served as a driver for the widespread use of digital technologies, compelling many players in the agri-food business to readily

embrace digital solutions to reduce disruptions. The article showcases many case studies in which digital technology has effectively increased productivity, ensured the safety of food, and boosted traceability. An example of this is the utilization of IoT and intelligent sensors in precision agriculture, which allows for the continuous monitoring of crop conditions in real-time. This has resulted in improved decision-making and more efficient allocation of resources.

However, the research also highlights substantial obstacles to the mainstream adoption of digital technology. These factors encompass expensive implementation expenses, farmers with little proficiency in digital technology, and insufficient infrastructure, particularly in rural regions. The authors highlight the necessity of making strategic investments and implementing supportive policies to effectively tackle these difficulties. They also advocate for a collaborative strategy including government, corporate sector, and academia to promote the development and expansion of digital solutions.

Hassoun et al. 2023, the researcher examines the incorporation of Fourth Industrial Revolution (4IR) technology into

the fruit and vegetable supply chain, with a specific emphasis on improvements in traceability systems. The authors present a current summary of how technologies like blockchain, IoT, AI, and smart sensors, collectively known as Traceability 4.0, are being used to improve transparency and efficiency in supply chains.

The report emphasizes the revolutionary capacity of these technologies in tackling significant obstacles such as food safety, quality assurance, and logistical inefficiencies. Through the utilization of blockchain technology, stakeholders can attain unchangeable and easily understood records of product journeys from the farm to the customer. This process enhances confidence and diminishes the likelihood of food fraud. The utilization of IoT devices and smart sensors allows for the continuous monitoring of environmental conditions, thereby guaranteeing the ideal storage and transportation of perishable commodities.

Sharvari patil et. al. 2023, paper provides a comprehensive analysis of digital tools that are transforming vegetable value chains. It specifically examines their influence on agricultural practices, supply chain management, and market access. The writers explore a range of digital advancements, such

as mobile applications, e-marketplaces, precision agricultural technologies, and data analytics platforms.

The report highlights the significance of mobile applications and e-marketplaces in connecting farmers and consumers, enabling direct sales, and decreasing reliance on intermediaries. This direct marketing strategy not only enhances the profit margins of farmers but also offers consumers fresher and more cost-effective goods. Furthermore, the utilization of precision farming technologies, facilitated by the Internet of Things (IoT) and data analytics, is emphasized due to its capacity to maximize the utilization of resources, improve agricultural yields, and reduce the negative effects on the environment.

Although there are potential advantages, the analysis highlights various obstacles that are impeding the implementation of digital tools in vegetable value chains. These factors encompass insufficient digital skills among farmers, insufficient infrastructure in rural locations, and elevated expenses related to sophisticated technologies. The authors propose that implementing focused training programs, government subsidies, and collaborations between the public and

commercial sectors could effectively address these obstacles and foster digital inclusion.

John Mark Truby 2023, the researcher explores the wider consequences of digital transformation in agriculture, highlighting the insufficiency of innovation alone in achieving widespread effect. The study contends that although digital solutions like as IoT, AI, and blockchain have shown considerable promise, their capacity to be expanded and maintained necessitates strong enabling frameworks.

The authors emphasize the crucial requirement for growth-stage funding and strategic investments to close the disparity between initial-stage innovation and widespread acceptance. Many digital agricultural solutions with potential often do not expand their reach due to insufficient access to funding and the high level of risk associated with digital agriculture in underdeveloped countries. The report references successful instances such as Twiga and Jumbo Tail, where digital platforms have been utilized to establish connections between farmers and markets. However, it acknowledges that such triumphs are very infrequent.

Moreover, the article examines the significance of rectifying structural

inefficiencies in domestic agricultural markets, specifically in developing nations. The presence of inefficiencies such as information gaps, logistical issues, and inadequate market linkages acts as obstacles that prevent digital solutions from reaching their maximum potential. The authors suggest that digital agricultural initiatives should prioritize the development of comprehensive market solutions that establish connections between farmers and buyers, offer up-to-date price information, and streamline supply chain management.

SCOPE OF STUDY

Agricultural digital transformation signifies a fundamental change in the way agricultural activities are carried out, supervised, and controlled. The use of sophisticated digital technologies is transforming all aspects of agriculture, encompassing production, supply chain management, marketing, and consumption. The digital transformation in agriculture encompasses various crucial domains:

1. **Precision agriculture:** precision agriculture also known as precision farming, utilizes Internet of Things (IoT) devices, drones, Global Positioning System (GPS), and sensors to gather data on soil

conditions, crop health, weather patterns, and insect presence. This data empowers farmers to make well-informed choices regarding planting, irrigation, fertilization, and pest management, hence maximizing resource utilization and enhancing agricultural productivity.

2. **Supply chain management:** SCM is improved by utilizing digital tools such as blockchain, artificial intelligence (AI), and data analytics. These techniques boost transparency and efficiency in the supply chain. Blockchain technology guarantees the capacity to track the entire journey of food products, starting from the farm and ending at the consumer's plate. This helps to minimize fraudulent activities and enhance the safety of food. Artificial intelligence (AI) and machine learning algorithms enhance the efficiency of logistics and inventory management processes, resulting in waste reduction and improved delivery times.
3. **E-marketplaces and mobile applications:** it enables direct sales between farmers and customers, skipping conventional intermediaries,

hence facilitating market access and direct marketing. By facilitating direct engagement, producers may enhance their profit margins and provide consumers with fresher products. Digital platforms facilitate improved price discovery and market access for small-scale farmers

4. **Financial inclusion:** FI is enhanced for farmers through the utilization of digital financial services such as mobile banking, digital payments, and online lending platforms. These services facilitate farmers' access to loans, insurance, and savings products, enabling them to effectively mitigate risks and make investments in agricultural enhancements.
5. **Extension Services and Education:** Digital platforms offer farmers convenient access to educational resources, comprehensive training programs, and extension services. Frontiers states that these platforms can provide farmers with knowledge about the most effective techniques, latest technologies, and market trends, enabling them to embrace novel approaches and enhance their productivity.

6. Automation and robots:

Automation technologies, including robots, are progressively employed in activities such as planting, harvesting, and packing. These technologies lower expenses related to workforce, enhance productivity, and enable accuracy in agricultural activities.

OPPORTUNITIES IN DIGITAL TRANSFORMATION

E-commerce platforms that facilitate the buying and selling of goods and services via the internet. Online markets offer a substantial chance for digital change in agriculture, namely in the realm of vegetable marketing from farmers directly to consumers. These platforms offer a digital environment where farmers can directly sell their agricultural products to consumers, avoiding the need for conventional middlemen.

Enhanced Market Accessibility: Online marketplaces broaden the scope of market penetration, enabling farmers to sell their products outside their immediate vicinity. This is especially advantageous for small-scale farmers who may otherwise have difficulties in reaching distant or metropolitan markets.

Increased Profitability: Online markets eliminate intermediaries, allowing farmers to obtain a larger portion of the ultimate selling price, resulting in bigger profit margins. Using this direct selling strategy enhances their profitability and can result in improved financial sustainability

Enhanced Price Discovery: These systems provide clear and open pricing mechanisms, enabling farmers to comprehend market demand and establish competitive prices. This level of transparency could result in more equitable pricing for farmers and consumers .

Data Insights: Online markets yield significant data regarding consumer preferences, purchase patterns, and market dynamics. This data can be utilized by farmers to make well-informed choices on crop planning, marketing strategies, and business development

Logistics and Distribution: Numerous online markets provide farmers with comprehensive logistics solutions, facilitating transportation and delivery. This guarantees the prompt delivery of fresh produce to clients in excellent condition, hence improving customer satisfaction and loyalty

Online advertising and promotion using social media platforms.

Social media platforms provide farmers with effective tools to promote their agricultural products, interact with consumers, and establish customer loyalty. Social media facilitates direct engagement between farmers and consumers, promoting the development of connections and the establishment of trust. Consistently providing information on farm operations, crop conditions, and yields helps cultivate a devoted consumer following.

1. Social media offers a cost-effective means of reaching a wide audience when compared to traditional marketing strategies. Farmers might utilize different social media platforms to advertise their products without requiring substantial financial resources.
2. Social media enables farmers to establish a distinctive brand identity and distinguish their products in the market. Discussing sustainable agricultural methods, organic cultivation, or distinctive crop varieties might appeal to specific consumers and command higher prices.

3. Social media platforms have advanced targeting capabilities, enabling farmers to effectively contact specific demographic groups by considering factors like geography, interests, and purchasing patterns. Implementing this focused strategy can enhance the efficiency of marketing initiatives and generate greater sales.
4. Social media enables farmers to receive prompt input from consumers, which they can utilize to enhance their products and services. Actively interacting with customer evaluations and comments can further improve customer satisfaction and loyalty.
5. Community Building: Farmers can establish and participate in virtual communities and associations centered around agriculture and local food movements. These communities can serve as a valuable resource for support, exchanging information, and collaborating on marketing initiatives.

BARRIERS TO DIGITAL TRANSFORMATION

A major obstacle to the advancement of digital transformation in agriculture is the insufficient level of digital literacy among

farmers. This difficulty is especially evident in rural areas where there is a lack of educational resources and technical infrastructure.

Insufficient Familiarity and Instruction:

Numerous farmers, particularly those belonging to older age cohorts, possess little familiarity with digital technologies. Unfamiliarity might result in reluctance to embrace new tools and systems. The lack of training programs in rural areas typically worsens this problem.

The complexity of digital tools:

Digital agricultural tools and platforms can be intricate, necessitating a certain degree of technical expertise to operate well. Individuals without fundamental digital literacy may have challenges in effectively utilizing modern tools, resulting in their underutilization and consequent feelings of frustration.

Accessibility Challenges:

Despite the existence of training programs, some farmers may face difficulties in accessing them due to factors such as geographical distance, financial limits, or time limitations. Agricultural workers frequently have rigorous schedules that allow limited time for participating in training courses.

Generational Divide: Younger farmers tend to possess greater technological proficiency and are more receptive to embracing novel technology, whereas older farmers may exhibit more skepticism and be less inclined to alter established techniques. It is essential to bridge this gap between generations in order to achieve universal acceptance of digital technology

To surmount these obstacles, it is crucial to implement focused educational programs and user-friendly technologies. Governments and agricultural organizations can significantly impact the farming community by offering specialized training programs and resources designed to meet farmers' needs.

Regulatory and Policy Issues

The adoption and use of digital technologies in agriculture are greatly influenced by regulatory and policy contexts.

Non-standardization:

The lack of uniform laws for digital tools and platforms can cause confusion and impede their adoption. Frontiers suggests that farmers may experience uncertainty around compliance requirements, data privacy, and security standards.

Complex Regulatory Frameworks: Agricultural policies and regulations in numerous places are intricate and scattered. Farmers may find it difficult to navigate these systems, particularly when incorporating digital instruments that may be subject to various regulatory authorities.

Privacy and security concerns around data are growing among farmers. The pace of technical innovations often outpaces the development of regulatory frameworks, resulting in deficiencies in data protection and the possibility of information being misused

Insufficient Policy Support: Certain regions suffer from a dearth of policies that promote and incentivize the adoption of digital transformation in the agricultural sector. Enacting policies that encourage investment in digital infrastructure, offer fiscal incentives for the adoption of technology, and facilitate research and development are essential for promoting digital adoption

To tackle these problems, it is imperative for governments and regulatory authorities to formulate unambiguous, uniform, and favorable laws that promote digital advancement while safeguarding the welfare of farmers. This involves establishing uniform protocols for the adoption of digital

tools, guaranteeing stringent restrictions for the protection of data privacy, and offering financial and technical assistance to farmers.

CONCLUSION

The adoption of digital technology in the marketing of vegetables directly from farmers to consumers represents a groundbreaking change that has significant consequences for the agriculture industry. This study has identified the significant prospects and significant obstacles associated with the incorporation of digital technologies into vegetable marketing.

The opportunities in this change are extensive and diverse. The utilization of online marketplaces and social media marketing has demonstrated substantial potential in improving market accessibility, augmenting profitability, and cultivating direct connections between farmers and customers. These systems facilitate more accurate determination of prices, decrease reliance on middlemen, and guarantee that fresher fruit is delivered to consumers. In addition, digital logistics and tracking systems, coupled with sophisticated inventory management tools, optimize the supply chain, improve operational efficiency, and reduce waste. These technologies offer immediate data insights, maximize resource utilization, and enhance quality control, ultimately resulting in more sustainable and resilient agricultural practices.

Nevertheless, the study also pinpointed crucial obstacles that must be resolved to fully achieve the advantages of digital

transformation. The farmers' limited digital literacy poses a substantial obstacle, impeding their capacity to successfully employ digital tools and platforms. The presence of ongoing maintenance and subscription fees can create financial obstacles that discourage consistent usage and acceptance. In addition, the presence of regulatory and policy challenges, such as the absence of standards and intricate compliance requirements, generate uncertainty and impede the smooth incorporation of digital solutions.

In order to surmount these obstacles, it is crucial to have a comprehensive and diverse strategy. Strategically designed educational programs and easily accessible technologies can help close the gap in digital literacy. Novel financing strategies, such as government subsidies and loans with low interest rates, have the potential to reduce financial limitations. Well-defined and encouraging legislative frameworks are essential for establishing a conducive atmosphere for digital transformation.

REFERENCES

1. "Barriers to Digital Transformation in Fruit and Vegetable Supply Chains: A Multicriteria Analysis Using ISM and MICMAC", M. Drechsler, A. Holzapfel, OPSEARCH ISSN: 0030-3887, 2022
2. "Digital Transformation in the Agri-Food Industry: Recent Applications and the Role of the COVID-19 Pandemic", Kumar et al., Frontiers in Sustainable Food Systems ISSN: 2571-581X, 2021
3. "Implementation of Relevant Fourth Industrial Revolution Innovations Across the Supply Chain of Fruits and Vegetables: A Short Update on Traceability 4.0", A. Hassoun, S. Kamiloglu, G. Garcia-Garcia, C. Parra-López, H. Trollman, S. Jagtap, R.M. Aadil, T. Esatbeyoglu, Food Chemistry ISSN: 0308-8146, 2023
4. "Revolutionizing Vegetable Value Chains: A Comprehensive Review of Digital Tools and Their Impact on Agriculture", Various, SSRN Electronic Journal ISSN: 1556-5068, 2023
5. "The Digital Agriculture Revolution Will Take More Than Innovation", Various, Boston Consulting Group (BCG), 2023