Sustainable Futures 10 (2025) 101422

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures

Digital transformation readiness and big data analytics in laying hen supply chains

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ARTICLE INFO

Keywords:
Laying hen farmers
Big data analytics
Supply chain
Digital transformation
Crbv
TAM

ABSTRACT

Digital transformation (DT), driven by a set of enabling technologies such as Big data analytics (BDA), Internet of Things (IoT), cloud computing, and mobile platforms, has become a pivotal catalyst for improving supply chain performance (SCP), especially in volatile and resource-constrained environments like the laying hen farming sector in Indonesia. This study investigates the relationships between DT, SCP, behavioral intention (BI), supply chain agility (SCA), operational supply chain transparency (OSC), and supply chain uncertainties (SCU). Employing a quantitative approach with multivariate analysis using Structural Equation Modeling (SEM) Partial Least Squares (PLS), data from 205 respondents were analyzed. The results reveal that DT significantly enhances BI and SCA but does not directly affect SCP or OSC. BI and SCA serve as mediators, connecting DT to SCP, while SCU moderates the BI-SCP relationship. These findings emphasize the critical roles of agility and behavioral readiness—particularly in the context of adopting big data analytics (BDA) in translating digital transformation into tangible supply chain benefits. The study also underscores the need for targeted interventions to foster digital literacy, infrastructure development, and collaboration among smallholder farmers. By advancing the contingent resource-based view (CRBV) and Technology Acceptance Model (TAM), this research contributes to the theoretical understanding of DT's impact in developing countries. Practical implications include policy recommendations for supporting digital adoption—especially BDA and enhancing supply chain resilience among livestock-based MSMEs. Future research should explore broader regional contexts, structural ownership influences, and long-term effects of DT on SCP.

1. Introduction

In recent years, businesses worldwide have faced heightened uncertainty due to the impacts of the COVID-19 pandemic [1–4]. A significant challenge has been the fragility of supply chains, exacerbated by government-imposed restrictions that have disrupted operational and logistical activities [5–7]. This disruption has made it increasingly difficult for businesses to maintain competitiveness as supply chain performance has deteriorated, with many enterprises even facing the risk of bankruptcy [8]. Additionally, agricultural price volatility has surged since the onset of the pandemic [9,10]. For instance, an empirical study by [11] found that agricultural production declined by 20 %, while global food prices increased by 25 % since the pandemic.

Research in the global context has demonstrated that digital transformation (DT) enabled by various technologies including Big data analytics (BDA), cloud computing, Internet of Things (IoT), and mobile platforms can significantly enhance supply chain performance (SCP). For example, findings from M. U [12]. indicate that the adoption of supply chain-supportive technologies reduces operational costs and improves responsiveness to market fluctuations. Similarly, an empirical study by [13] highlights how big data analytics can enhance the accuracy of business planning and decision-making for products prone to price volatility. Recent studies, such as [14] on the "Impact of digital transformation on supply chain efficiency: a parallel mediation model" and [15] on the "Impact of certification on efficiency: a study of the inverted U-shaped moderating role of supply chain complexity," reinforce these insights by underscoring the critical role of mediating and moderating mechanisms in shaping supply chain outcomes. While these

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https://doi.org/10.1016/j.sftr.2025.101422
Received 17 April 2025; Received in revised form 25 August 2025; Accepted 7 October 2025
Available online 14 October 2025
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works primarily provide evidence within manufacturing and certification contexts, the present study extends this discourse to the agricultural domain, specifically the laying hen sector, which is predominantly characterized by smallholder farmers. However, the capacity to adopt such transformative technologies remains limited among small businesses, primarily due to resource constraints, making them less adaptable to technological advancements [16,17]. Despite these challenges, technology has been shown to play a crucial role in improving financial capabilities, which, in turn, supports long-term business productivity [18]. Moreover, an empirical study conducted by [19] demonstrates that technology adoption also aids business leaders in making more informed decisions, underscoring its vital role in contemporary supply chain management.

To address these challenges, a structured approach is required to enhance farmers' readiness and behavioral intention to adopt digital technologies. Among the most impactful tools is Big data analytics (BDA), a set of methods for analyzing and extracting value from vast and complex datasets [20–22]. In the laying hen industry, which plays a crucial role in food security and inflation dynamics in Indonesia, BDA supports digital transformation by enabling real-time monitoring and management of production, distribution, and market trends. Price volatility in this sector is often exacerbated by oversupply and weak information systems. BDA helps mitigate such issues by improving supply-demand forecasting, allowing for more balanced inventory and pricing strategies [23]. However, institutions supporting the laying hen industry remain underdeveloped, leaving farmers with limited digital literacy and access to timely market information [24,25].

Big data analytics (BDA) offers the potential to address these challenges by improving the availability, quality, and management of information across the supply chain [26–28]. BDA enables the analysis of large and diverse data sets to produce actionable insights for demand forecasting, inventory optimization, and strategic planning [29]. Its predictive capabilities support price stability by minimizing the risks associated with supply-demand mismatches. For instance, BDA has been shown to reduce the bullwhip effect, thereby promoting supply chain coordination and responsiveness to external shocks. In the context of laying hen farming, BDA can enhance resilience by enabling data-driven decisions that stabilize egg production and pricing.

Therefore, Big data analytics (BDA) innovation can assist laying hen farmers in addressing over-supply issues by enabling the storage and management of data and information related to the distribution of Day-Old Chicks (DOC). Moreover, the adoption of digital technologies through BDA supports business owners by streamlining data and information management, enhancing operational efficiency, and improving supply chain performance. These capabilities allow businesses to maintain competitiveness amidst environmental uncertainties and global economic fluctuations (D. Q [30–32].

Studies conducted in international contexts highlight that digital transformation through enhanced connectivity, integration, and automation is a key enabler of the behavioral intention to adopt big data analytics [33–35]. For instance, [36], emphasize that robust digital infrastructure and resource complementarities influence organizational readiness for advanced analytics technologies. However, it is not digital transformation per se, but the underlying capabilities such as IT flexibility, platform integration, and digital literacy that determine successful adoption [37]. Organizations with a supportive digital culture and infrastructure are more likely to embrace BDA for strategic decision-making [38].

In addition, studies in the international environment also prove that there is a relationship between digital transformation and operational supply chain transparency. For example, the findings in Yin's (2022) study show how digital transformation improves the operational transparency of the supply chain by integrating advanced technologies such as blockchain and RFID, which increase data visibility and resilience. This study emphasizes the complex causal relationship between digital transformation and supply chain resilience, indicating that effective resource allocation and technology implementation are critical to achieving transparency and adaptability in the supply chain. Ma et al. (2022) in the pharmaceutical sector discuss how digital transformation improves operational transparency of the supply chain by emphasizing the role of information sharing and traceability in the pharmaceutical sector. This study reveals that improved traceability, facilitated by digital technology such as farm monitoring apps, IoT sensors, data analytics tools, directly contributes to sustainable supply chain performance, thereby increasing transparency and efficiency in operations.

Previous studies conducted across various countries have also established a strong link between digital transformation and supply chain agility. For instance, [39] demonstrated that supply chain digitalization significantly enhances operational agility by showing how supply chain traceability and agility mediate the relationship between digitalization and performance. This relationship emphasizes how advanced technologies embedded in digital transformation, such as big data analytics support rapid responsiveness in complex environments. Additionally, research by [40] and [41] highlights the role of Behavioral Big data analytics Analysis in improving supply chain performance. The study illustrates how knowledge derived from business operations and inter-organizational relationships enables business actors to respond more swiftly to supply chain dynamics caused by shifts in market conditions and consumer demand [40]. Furthermore, it confirms the mediating role of behavioral intention in linking digital transformation to supply chain performance.

In another example, Giri and Manohar (2021) explore how behavioral intention mediates the adoption of blockchain technology in the supply chain, revealing that perceived usefulness and perceived ease of use significantly influence the intention to adopt such technologies. This framework applies to both developed and developing countries and across organizations of varying scales, from large corporations to SMEs. Moreover, Hernández-Espallardo et al. (2010) studied manufacturing firms in Colombia and highlighted the role of inter-firm knowledge sharing and effective governance mechanisms in enhancing supply chain performance. It emphasizes that trust and behavioral control are essential for fostering collaborative environments that enable learning and knowledge exchange. These findings reinforce the notion that behavioral intention is pivotal in driving digital transformation across diverse contexts, including large enterprises and SMEs in advanced and emerging economies.

Previous research has highlighted the role of operational supply chain transparency as a mediating factor in the relationship between digital transformation and supply chain performance. For instance, Pyun and Rha (2021) underscores the growing significance of digital transformation within supply chain operations and emphasizes the critical need for operational transparency to achieve sustainable management and resilience. This study highlights that real-time monitoring and end-to-end visibility are essential for companies to respond effectively to disruptions, thereby mediating the impact of digital transformation on supply chain performance. However, it does not employ a multivariate approach to comprehensively examine the relationships between these constructs. Similarly, Ishfaq et al. (2021) explore the impact of digital transformation on operational transparency in retail supply chains, demonstrating its importance in enhancing overall supply chain performance. This research emphasizes the value of integrated reporting and real-time visibility, which enable companies to adapt swiftly to market changes. By fostering operational transparency, digital transformation indirectly contributes to improving the efficiency and effectiveness of supply chain operations.

In addition, this study highlights the mediating role of supply chain agility in the relationship between digital transformation and supply chain performance. For example, research conducted by Rehman et al. (2020) on manufacturing companies in Saudi Arabia demonstrates the importance of supply chain agility in responding to dynamic market demands across both developed and developing countries, as well as for large businesses and SMEs. Supply chain agility enables organizations to

adapt swiftly to changes, thereby mediating the impact of digital transformation on overall supply chain effectiveness.

Moreover, past studies have also established the role of supply chain uncertainties as a moderating variable. For instance, findings from [42] in manufacturing companies reveal that supply chain uncertainties moderate the relationship between supply chain flexibility and performance. These results indicate that in periods of uncertainty, businesses often increase flexibility by adjusting production processes and reorganizing supply chain operations to mitigate risks and maintain efficiency [43].

Although the significance of adopting big data analytics (BDA) and other advanced technologies to support supply chains has been well-documented in several developing countries, there is still a lack of research focusing on livestock commodities, particularly laying hens. This sector is predominantly composed of smallholder farmers operating at varying scales, such as micro, small, and medium enterprises. The adoption decisions of these businesses differ significantly based on their size, presenting unique challenges and opportunities for achieving improved supply chain performance.

This study makes three key contributions. Theoretically, this study advances the understanding of supply chain performance by exploring the roles of digital transformation, operational supply chain transparency, behavioral intention to BDA, and supply chain agility. Second, this study supports strategic food productivity in the poultry sector, particularly egg production, by demonstrating how BDA-driven digital transformation enhances data transparency across upstream and downstream operations. This transparency helps mitigate disruptions caused by over-supply in the laying hen industry. Third, this study provides practical insights for helping smallholder farmers navigate supply chain uncertainties stemming from market turbulence in developing countries, with a focus on micro, small, and medium enterprises (MSMEs). Additionally, this study aligns with and contributes to the United Nations Sustainable Development Goals (SDGs), specifically Goal 1: No Poverty, Goal 8: Decent Work and Economic Growth, and Goal 10: Reduced Inequalities.

2. Theoretical background and hypotheses development

This section presents the result of a critical analysis of previous studies, particularly about the theory of dynamic capabilities. It examines the relationships between digital transformation and operational supply chain transparency, behavioral intention to adopt BDA and supply chain agility. Additionally, it explores the interplay between operational supply chain transparency and supply chain agility in shaping the behavioral intention to adopt BDA.

Furthermore, this section builds the theoretical logic connecting operational supply chain transparency and supply chain agility to supply chain performance. Operational transparency defined as the ability to access and share real-time, accurate, and relevant information enables firms to anticipate disruptions and coordinate responses more effectively. This transparency supports agility, which reflects the capability to rapidly adapt to environmental changes such as market volatility or supply shocks. Together, transparency and agility are theorized to reinforce each other in enhancing supply chain performance.

The section further investigates the connections between operational supply chain transparency, behavioral intention to adopt BDA, and supply chain agility and how these collectively influence supply chain performance. A specific focus is given to the mediating role of behavioral intention to adopt BDA in the relationship between digital transformation and supply chain performance. Moreover, this study also addresses how behavioral intention to adopt BDA mediates the linkages between operational supply chain transparency and supply chain performance, as well as between supply chain agility and supply chain performance.

This section also highlights the moderating role of supply chain uncertainties in the relationship between behavioral intention to adopt BDA and supply chain performance. In addressing these complex relationships, we identified several research gaps that had not been sufficiently explored in prior studies, particularly those concerning livestock commodities. Special attention is given to the typology of laying hen businesses within the MSME sectors in developing countries, providing a foundation for deeper investigation into this critical area.

2.1. The relationship between digital transformation and operational supply chain transparency

Previous studies have demonstrated the significant role of digital technology in enhancing operational supply chain transparency. For instance, a study by [44] employed a qualitative approach, revealing that training programs aimed at improving digital skills, business operations, and fostering a digital mindset positively impact supply chain transparency. Similarly, a study by [45] confirmed the positive influence of technology on supply chain transparency. However, to date, there has been no quantitative study exploring how digital transformation affects operational supply chain transparency in the context of developing countries, particularly within the laying hen commodity sector. This gap is particularly notable when considering the typology of MSME in these countries. Given the challenges faced by laying hen businesses, entrepreneurs must understand the role of digital transformation in improving operational transparency within their supply chains.

H1. *Digital Transformation has a positive impact on Operational Supply Chain Transparency*

2.2. The relationship between digital transformation and behavioral intention to adopt big data analytics

The results of a study by [46] indicate that technology influences the intention of entrepreneurs in Malaysia to adopt blockchain technology. Specifically, the study identifies relative advantage and complexity as key technological factors, noting that anxiety toward technology can result in lower adoption rates [47]. Building on this, digital transformation can similarly influence the behavioral intention to adopt big data analytics. This is because digital transformation facilitates greater and higher-quality access to data and information, enabling better insights for decision-making in the laying hen business. Furthermore, digital transformation introduces more advanced and efficient technologies for data processing and analysis, which can enhance stakeholder confidence in utilizing big data analytics. However, despite these advancements, studies examining the impact of digital transformation on behavioral intention, particularly regarding the adoption of big data analytics, remain limited. Moreover, there is a notable gap in research focusing on dynamic and economically elastic sectors, such as the strategic food sector, specifically within the laying hen industry. This study is critical in addressing business challenges, particularly the lack of data and technology in community farms.

H2. *Digital Transformation has a positive impact on Behavioral Intention to Adopt Big Data Analytics*

2.3. The relationship between digital transformation and supply chain agility

The results of an empirical study conducted by [48] indicate that the flexibility of technology and information infrastructure, coupled with the effective assimilation of information technology, plays a significant role in enhancing supply chain agility among business owners in China. This is because business owners with strong technological and information management capabilities are better equipped to manage knowledge effectively [49]. The ability to handle information technology is a key factor in enabling business owners to elevate their skills from lower- to higher-order capabilities [50]. Additionally, a study conducted by [51] on three companies in the garment and textile sectors

in China, Malaysia, and Vietnam found that competencies in IT, IT integration, and IT flexibility contributed to improved supply chain agility. Technology is deemed crucial for business owners, and the study further highlights that the business environment encourages the integration of IT to acquire the necessary resources for achieving supply chain agility [51]. According to [52], information integration is vital, even considered a prerequisite for establishing an agility paradigm. Moreover, another study by [53] focused on IT integration and demonstrated that it enhances the ability of business owners to respond more flexibly to changes in the supply chain. However, thus far, no study has specifically examined the role of digital transformation in enhancing supply chain agility in dynamic product sectors, such as the laying hen industry, which must be particularly responsive to market fluctuations.

H3. *Digital Transformation has a positive impact on Supply Chain Agility*

2.4. The relationship between digital transformation and supply chain performance

The results of a study conducted by [54], which focused on 306 companies across Asia, Africa, and Europe, demonstrated that digital transformation has a significant impact on supply chain performance. Similarly, research conducted by [55] in Morocco on manufacturing companies also confirmed the role of digital transformation in enhancing supply chain performance. Additionally, a study by [56] on a pharmaceutical company showed that digital transformation positively influences supply chain performance. These studies highlight that digital technologies can automate production, shipping, and inventory management processes, leading to improved efficiency and reduced operational costs. Furthermore, digitalization enables companies to obtain real-time data, allowing them to better forecast consumer demand, reduce lead times, and expedite product delivery, thereby increasing customer satisfaction and strengthening the company's brand image. However, to date, no studies have specifically examined the role of digital transformation in achieving better supply chain performance within the context of the laying hen industry.

H4. *Digital Transformation has a positive impact on Supply Chain Performance*

2.5. The relationship between operational supply chain transparency and supply chain performance

The results of a study conducted by [57], focusing on automotive companies, demonstrated that supply chain transparency can enhance business performance. Similarly, [58] found that the availability of open information helps business leaders improve supply chain performance. This study highlights that supply chain transparency not only improves operational efficiency and supply chain effectiveness but also assists businesses in identifying and mitigating risks within the supply chain. However, prior studies have primarily focused on large-scale manufacturing firms, leaving a gap in understanding how transparency operates in fragmented sectors such as poultry farming in developing countries. Therefore, it is crucial for businesses to effectively manage transparent information to support the achievement of optimal supply chain performance.

H5. *Operational Supply Chain Transparency has a positive effect on Supply Chain Performance.*

2.6. The relationship between behavioral intention to adopt big data analytics and supply chain performance

The results of the study by [58] demonstrate a significant relationship between information transparency and supply chain performance. Transparent information enables companies to explore alternative decision-making options. Additionally, [59] highlight that information transparency within businesses contributes to enhanced profitability. This suggests that the availability of data through big data analytics can assist business leaders in analyzing large and complex datasets, enabling the generation of more accurate and valuable insights for decision-making. Given that supply chain performance is crucial for the success of businesses and industries, it is essential to understand the factors influencing the behavioral intention to adopt big data analytics for improving supply chain performance. This is especially true for livestock supply chains where limited digital capacity and low data literacy hinder real-time data utilization. However, to date, no studies have examined this in the context of livestock, particularly for laying hen commodities, which are sensitive to market fluctuations.

H6. *Behavioral Intention to Adopt Big Data Analytics has a positive effect on Supply Chain Performance (belum)*

2.7. The relationship between supply chain agility and supply chain performance

The results of the study by [60] demonstrate a positive effect on supply chain performance. Similarly, the findings by [61] indicate that supply chain agility significantly impacts supply chain performance. Information derived from supply chain agility enables business leaders to enhance overall performance. Furthermore, a study by [62] focusing on manufacturing companies in India confirmed that supply chain agility contributes to improved supply chain performance. These studies underline the critical role of agility in optimizing supply chain performance. In contrast, in a supply chain where businesses are less agile and unable to respond swiftly to changes, performance may suffer, leading to increased production costs and decreased product and service quality. Therefore, companies must prioritize supply chain agility and develop effective strategies to improve performance. However, to date, no study has examined the role of supply chain agility in the egg-laying chicken business, particularly in developing countries where businesses are categorized by micro, small, and medium typologies.

H7. *Supply Chain Agility has a positive effect on Supply Chain Performance*

2.8. The relationship of behavioral intention to adopt big data analytics to supply chain performance moderated by supply chain uncertainties

The study results by [42] highlight the role of supply chain uncertainties in moderating smart supply chains' impact on supply chain flexibility, as well as moderating the relationship between supply chain flexibility and supply chain performance. However, there has yet to be a study that focuses on the role of supply chain uncertainty in moderating the relationship between Behavioral Intention to Adopt big data s and supply chain performance. The study by [42] indicates that risks and uncertainties are prevalent in supply chain activities, especially when dealing with economic fluctuations or changes in government policies. These findings suggest that business leaders must consider various factors influencing technology adoption decisions, as uncertain conditions can significantly impact the relationship between Behavioral Intention to adopt big data analytics and supply chain performance."

H8. *Supply Chain Uncertainties moderate the influence of Behavioral Intention to Adopt Big Data Analytics on Supply Chain Performance*

2.9. The relationship between digital transformation and behavioral intention to adopt big data analytics mediated by operational supply chain transparency

The study results by [63] illustrate the relationship between technology, intention, and supply chain. However, the study did not explore the role of Operational Supply Chain Transparency in explaining the adoption of big data analytics in developing countries, where adoption remains uneven, and many businesses have yet to embrace it.

Understanding the factors that influence behavioral intentions to adopt BDA is crucial for business leaders. Therefore, operational supply chain transparency should be considered by digitally transformed companies as a key factor in driving the intention to adopt big data analytics.

H9. *Operational Supply Chain Transparency mediates the influence of Digital Transformation on Behavioral Intention to Adopt Big Data Analytics*

2.10. The relationship between digital transformation and supply chain performance mediated by behavioral intention to adopt big data analytics

The results by [63] demonstrate the relationship between the three aspects, but the study did not focus on the egg-laying chicken business with big data analytics, as it was centered on blockchain technology. Therefore, there has been no research proving the role of Behavioral Intention to adopt big data analytics in mediating Digital Transformation and its impact on Supply Chain Performance. Digital transformation has become a key focus to improve business efficiency and productivity [64]. Meanwhile, a study by [65] results indicate that digital transformation encourages business leaders to adopt technology to optimize their supply chains. In this context, behavioral intention plays a crucial role in the successful adoption of big data analytics . One way to enhance this behavioral intention is by fostering communication and support from supply chain partners. However, to the best of our knowledge, no study has examined the role of Behavioral Intention to Adopt Big Data Analytics in mediating Digital Transformation and Supply Chain Performance, particularly in the context of developing countries.

H10. *Behavioral Intention to Adopt Big Data Analytics mediates the influence of Digital Transformation on Supply Chain Performance.*

2.11. The relationship between digital transformation and behavioral intention to adopt big data analytics mediated by supply chain agility

The results by [63] show a relationship between technology and Behavioral Intention to Adopt blockchain through agility. However, the study did not explore the adoption of big data analytics. In reality, the relationship between digital transformation, behavioral intention to adopt big data analytics, and supply chain agility is complex and interrelated. Digital transformation enables organizations to leverage big data analytics to enhance their supply chain agility [66]. Moreover, supply chain agility improves an organization's ability to adopt and use big data analytics more effectively, as it allows them to adjust and optimize processes through better data management systems [67].

H11. *Supply Chain Agility mediates the influence of Digital Transformation on Behavioral Intention to Adopt Big Data Analytics*

3. RESEARCH method

3.1. Measurement of research variables

This study observes variables related to supply chain performance, focusing on digital transformation, operational supply chain transparency, behavioral intention to adopt big data analytics and supply chain agility. Each construct is measured using a Likert scale, ranging from strongly disagree (1) to strongly agree (5).

The variables examined in this study include microfinance, poverty reduction, entrepreneurial success, subjective well-being, and the moderating variables of ownership structure—categorized into family and non-family businesses—and gender. Microfinance is measured using four indicators adopted from previous empirical studies (S. H [68]).: microloans, micro-savings, insurance, and microcredit. The latent variable of poverty reduction, also adopted from prior studies [69], comprises five reflective indicators: mitigating structural poverty, improving the business ecosystem, increasing per capita income, enhancing the economic conditions of the community, and offering investment opportunities and business ideas. Entrepreneurial success, another reflective latent construct, is measured using indicators from [70,71]: satisfaction in providing opportunities for others to join the business, owner involvement in the business, profitability, perceived opportunities for success, and satisfaction in leading one's own company. The dependent latent construct, subjective well-being, includes indicators such as satisfaction with work methods, the ability to build good relationships with neighbors, satisfaction with the living environment, and satisfaction with family life [39,72–74]. The measurement instrument for all constructs employs a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Table 1, Table 2, Fig. 1, Fig. 2

3.2. Questionnaire development

The purpose of this study was to develop a questionnaire based on a comprehensive review of the literature. The research constructs were designed to align with the study's objectives, which include: 1) examining the influence of attribution on business growth, 2) analyzing the impact of motivation on business growth, 3) exploring the moderating role of experience in the relationship between attribution and business growth, and 4) investigating the moderating role of experience in the relationship between motivation and business growth. The study employs multivariate analysis, which involves two stages of testing: the outer model and the inner model. The outer model testing focuses on validity and reliability assessments, ensuring that the constructs are accurately measured. The inner model testing then evaluates the relationships between the constructs using Structural Equation Modeling (SEM) analysis, facilitated by SmartPLS 3.0 software.

3.3. Research location and respondents

The study was conducted in East Java and Central Java, using a purposive sampling method to select areas with the largest populations of laying hen farmers in Indonesia. This selection was based on data from the Directorate General of Animal Husbandry and Animal Health (2014–2018) and DataIndonesia.id (2011–2021). For Central Java Province, the study focused on Kendal Regency, identified as having the largest population of laying hen farmers, according to [87]. In East Java Province, the study was conducted in Blitar Regency, which was similarly identified in [88] as having the highest population of laying hen farmers in the province. According to Statistics Indonesia (BPS), these areas consistently maintain the largest populations of laying hen farmers in their respective provinces. To select the respondents, a multistage random sampling method was applied. In the first stage, the regencies of Kendal and Blitar were selected. The second stage involved choosing subdistricts within those regencies—Sukorejo in Kendal and Ponggok in Blitar. Finally, the villages of Sukorejo and Ponggok were selected from each respective subdistrict. This approach resulted in 103 respondents from Kendal Regency and 102 respondents from Blitar Regency, forresulting a total of 205 respondents. This sample size aligns with the recommendations of [89], which state that the minimum sample size for partial least square studies is between 30 and 100 respondents.

The study was conducted over three months, from August to November 2024. Quantitative data analysis was carried out using Structural Equation Modeling (SEM) with SmartPLS software. The results of the modeling were subsequently discussed with stakeholders including laying hen farmers, PINSAR (a laying hen business organization) representatives, local livestock services, and academics—through Focus Group Discussions (FGDs). This study limits the terminology of digital technology to the SMACIT framework: Social, Mobile, Analytics, Cloud, and Internet of Things (IoT). Social refers to social media; Mobile encompasses devices such as cellphones and laptops; Analytics involves tools like Microsoft Excel for data analysis; Cloud refers to platforms like Google Drive and Dropbox; and IoT refers to internet usage in general.

Table 1
Research Variables and indicators.

Measurement
Digital Transformation (X1) [75–78]
Sensing
I always drive new business processes by building SMACIT technology changes
I start integrating digital technology to drive my business changes
I start switching to digital technology intensively in certain business activities
Seizing
I believe that my adoption of digital technology allows me to reduce the risk of supply chain performance in my business
I believe that my adoption of digital technology helps my business to be more flexible in supply chain management
Transforming
I use digital technology to interact with customers
I use digital technology to interact with suppliers
I believe that using the Internet helps me to improve my relationship with customers
I believe that using digital technology helps me to be able to adjust products to customer demand
By using digital technology, I believe that I can reduce product delivery costs
Operational Supply Chain Transparency (Y1) [63]
I believe that big data analytics helps us in sharing operational plans (e.g., distribution plans, production plans) related to product design information among supply chain partners.
I believe that big data analytics helps us in sharing operational information (e.g., quantity of products distributed, process, delivery quality, stock) among supply chain partners.
I believe that big data analytics helps us in sharing strategic information (e.g., new orders, product demand, internal and external conditions or supply and demand and government regulations)
Supply Chain Agility (Y2) [63,79,80]
I believe that big data analytics helps me to be efficient in production time until delivery to consumers
I believe that big data analytics helps me to introduce new products other than chicken eggs
I believe that big data analytics can improve my ability in product delivery.
Big data analytics helps me to improve customer service
Big data analytics helps me to adapt to market changes for chicken eggs
Behavioural Intention to Adopt BDA (Y3) dari [46,63,81]
I intend to adopt big data analytics in my business
I intend to use big data analytics in the future
I also recommend big data analytics to be used by the government and companies so that we can coordinate well
I intend to use big data analytics to support egg supply chain activities
I intend to change supply chain operations and management with big data analytics
Other job injustices
Supply chain performance (Z) [82–84]
The logistics cost of broiler eggs tends to be low
We have achieved profits
We have egg products
Many of our customers are satisfied
Our egg delivery process is on time
We respond quickly to changes in consumer demand
We are able to efficiently respond to market price fluctuations for broiler egg products
Suppply chain uncertainties (a) ([83,85,86])
Our business is highly dependent on suppliers to carry out the production process
I am able to predict egg demand patterns
I am able to estimate changes in egg prices
I am able to estimate egg deliveries on time
I know the exact number of egg suppliers

4. EMPIRICAL results

Based on the results of the study conducted using survey, interview, and observation methods with 205 laying hen farmers from the highest egg production centers in Indonesia, the detailed social and economic characteristics of the respondents are presented in the following table.

4.1. Analysis of validity and reliability

The reliability and validity of the outer model were further confirmed using the results of indicator loadings, Cronbach's Alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE), as summarized in Table 3. All constructs demonstrate acceptable internal consistency reliability, as all CR values exceed the recommended threshold of 0.70 [90], ranging from 0.861 (Behavioral Intention) to 0.921 (Supply Chain Agility). Similarly, the Cronbach's Alpha values for all constructs also surpass the 0.70 minimum criterion, with the lowest being 0.759 for Operational Supply Chain Transparency, indicating satisfactory internal reliability.

In terms of convergent validity, all constructs reported AVE values greater than 0.50, suggesting that the indicators explain >50 % of the variance of their respective constructs. The highest AVE is observed in Digital Transformation (0.715) and Supply Chain Agility (0.701), while Behavioral Intention to Adopt Big data analytics has the lowest AVE at 0.554, but still meets the acceptable threshold.

The indicator loadings also show that most items meet the minimum loading value of 0.5, indicating that individual indicators significantly contribute to their respective latent constructs. For example, items X1.2 and X1.3 (Digital Transformation) have very high loadings (0.907 and 0.915), which strengthens the construct's reliability. Meanwhile, a few indicators such as Z7 (0.621) and Y2.1 (0.691) have relatively lower but still acceptable loading values.

The SRMR value was observed at 0.093, aligning with [90] guideline that an ideal SRMR value for outer model testing is 0.10. Similarly, the NFI value was 0.682, which falls within the ideal range of 0 to 1, as stated by [91]. These findings, confirm that the outer model possesses good model fit, acceptable internal consistency, and sufficient convergent validity, allowing the structural (inner) model to be evaluated with confidence.

4.2. Structural model evaluation

4.2.1. R-square (R^2)

For the inner model, the evaluation was conducted to determine how much the independent variable contributes to the dependent variable, represented by the R-squared (R^2) value . R^2 values range between 0 and

Table 2
Respondents' Profiles.

Description	(*n* = 205)	
	Respondent Profile	
	Number (person)	Percentage (%)
Farmer age		
26–35	22	10.7
36–45	66	32.2
46–55	45	22
56–65	72	35.1
Gender		
Male	178	86.8
Female	27	13.2
Education		
No education	7	3.4
Primary school	25	12.2
Junior school	76	37.1
Senior school	77	37.6
Graduate	20	9.7
Postgraduate	0	0
Experience		
10 years	28	13.6
11–15 years	127	62
>15 years	50	24.4
Market Dynamics		
COVID-19	30	14.6
Market Fluctuation	170	83
Climate Change	5	2.4

1, with thresholds of 0.67 considered substantial, 0.33 moderate, and 0.19 weak; higher values suggest greater explanatory power [92,93]. In the current study, the R^2 value for supply chain performance is 0.787, suggesting that the model accounts for 78.7 % of the variance in supply chain performance. This level of predictive power is considered substantial. Thus, the independent variables in the model play a significant role in explaining variations in supply chain performance.

4.2.2. Hypothesis test

Table 4 presents the hypothesis testing of the empirical model specification regarding the role of experience in moderating the relationship between entrepreneurial cognition and business growth.

The analysis results reveal a complex interlink between latent constructs, including digital transformation, operational transparency, supply chain agility, behavioral intention to adopt big data analytics, and supply chain performance. This study offers valuable insights into the effectiveness of digital transformation, as well as the mediating and moderating roles of various factors in enhancing supply chain performance. Below are the detailed results of the SEM-PLS analysis based on the inner model test.

a. H1 is rejected (β=0.126, $p = 0.067$). This empirical study proves that digital transformation (DT) does not affect supply chain performance (SCP). This shows that farmers who have transformed digitally cannot immediately improve supply chain performance.
b. H2 is accepted (β=0.198, $p = 0.010$), which means that digital transformation effectively increases behavioral intentions to adopt big data analytics. This emphasizes the importance of digital technology in driving organizational awareness and readiness for big data analytics.
c. H3 is accepted (β=0.220, $p = 0.001$), this study shows that digital transformation drives supply chain agility.
d. H4 is rejected (β=−0.030, $p = 0.393$), indicating that digital transformation does not affect supply chain performance.
e. H5 is rejected (β=−0.014, $p = 0.767$). This study shows that operational supply chain transparency (OSC) does not affect supply chain performance (SCP)
f. H6 is accepted (β=0.272, $p = 0.000$), indicating that behavioral intention to adopt Big data analytics plays an important role in improving supply chain performance.

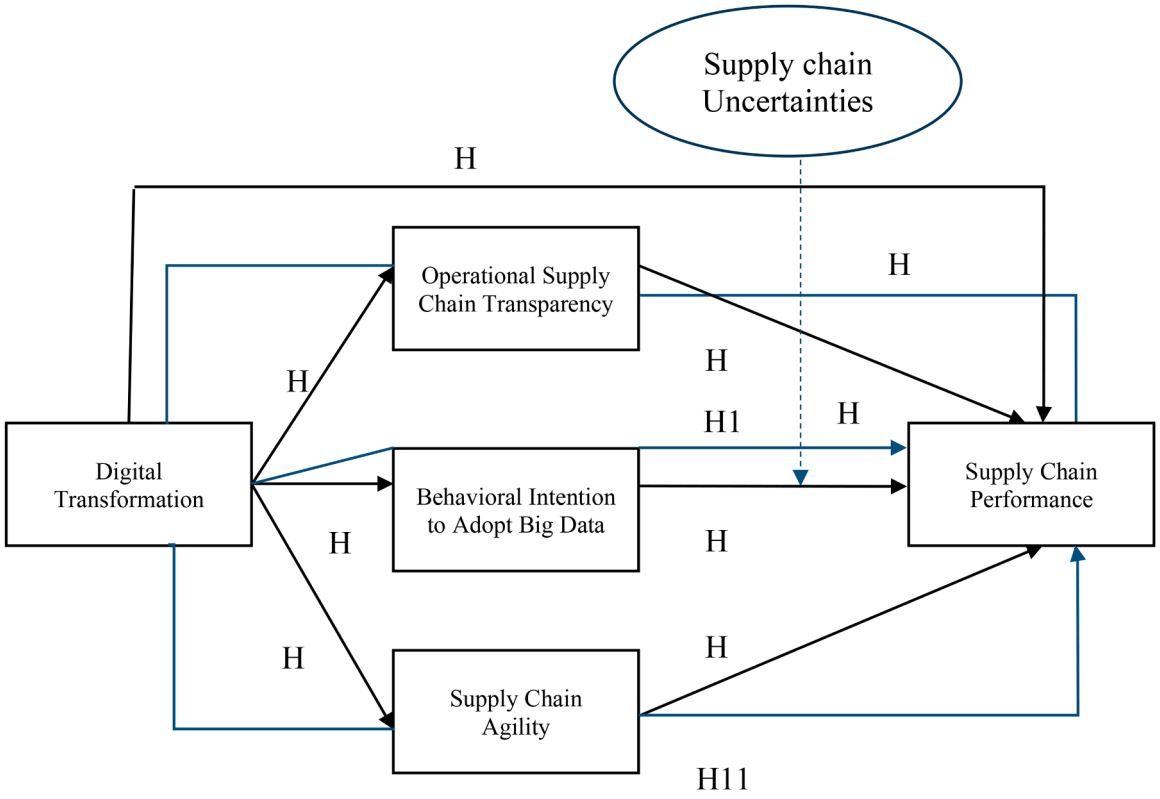

Fig. 1. Hypothesis Testing Empirical Model Specification The role of experience in moderating entrepreneurial cognitive with business growth.

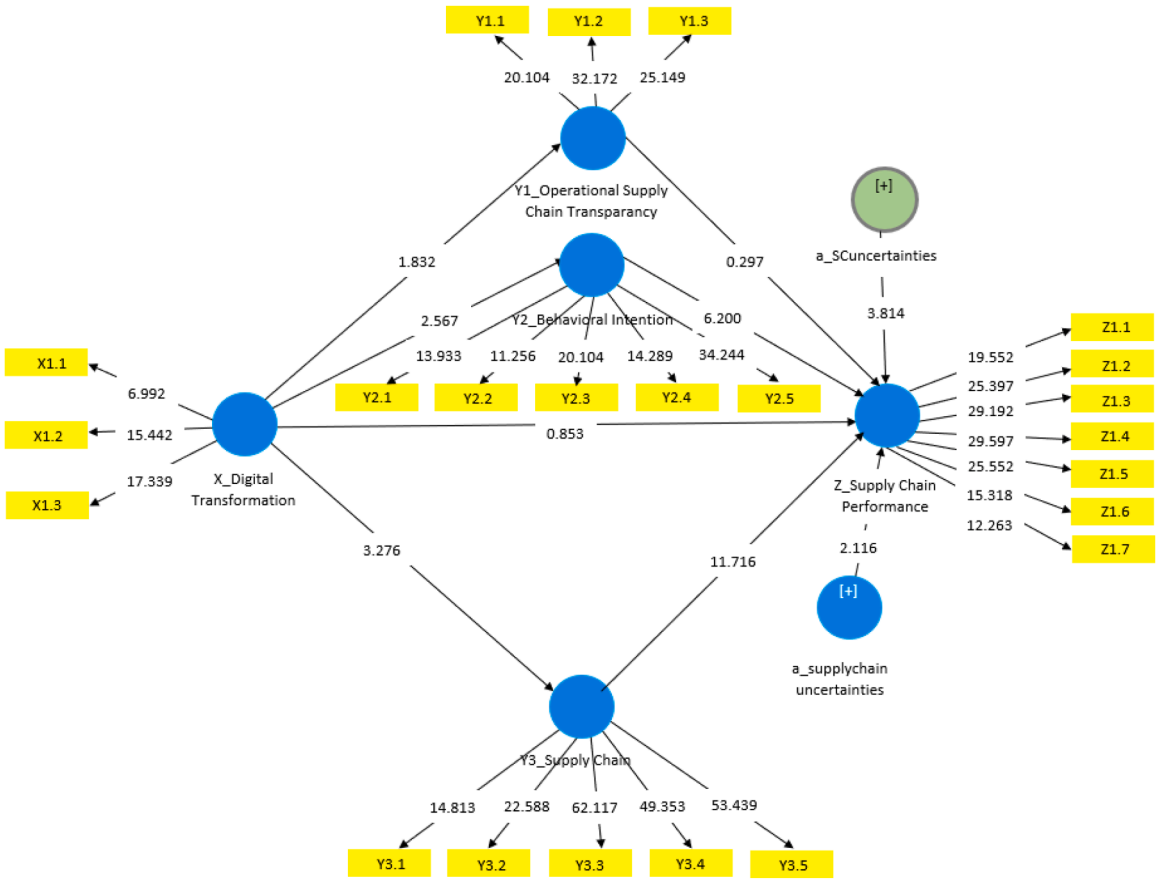

Fig. 2. Empirical Model of Collaboration of Contingent Resource-Based View (CRBV) Theory and Technology Acceleration Model (TAM) in Mediating Digital Transformation on Supply Chain Performance with Moderation of Supply Chain Uncertainties in Developing Countries.

g. H7 is accepted (β=0.674, $p = 0.000$). This study explains that supply chain agility is a key element in improving supply chain performance.
h. H8 is accepted (β=−0.101, $p = 0.000$). Supply chain uncertainty acts as a significant moderator, indicating that organizations need to consider external risks and uncertainties in decision-making.
i. H9 is rejected (digital transformation → operational transparency → supply chain performance) is not significant (β=−0.002, $p = 0.799$). This study proves that operational supply chain transparency does not mediate the impact of digital transformation (DT) on supply chain performance (SCP)
j. H10 is accepted (digital transformation → behavioral intention → supply chain performance) significantly (β = 0.054, $p = 0.024$). This study highlights that intention to adopt big data analytics fully mediates the impact of digital transformation (DT) on supply chain performance (SCP)
k. H11 is accepted (β = 0.148, $p = 0.002$). This study proves that supply chain agility plays an important role in fully mediating the influence of digital transformation on supply chain performance, especially in the laying hen business in developing countries.

5. Discussion of the empirical findings

This study not only tests theoretical relationships but also grounds them in the operational realities of MSMEs in the laying hen industry. The alignment between assumptions and field data was ensured by integrating practitioner insights and real-world challenges into the model design. As such, the empirical findings serve not only as statistical validation but also as practical affirmation of the model's assumptions. In the study locations of Blitar (East Java) and Kendal (Central Java)—recognized as key egg production centers in Indonesia—field observations confirmed the presence of digital transformation constraints such as limited internet connectivity, aging farmer populations with low digital literacy, and minimal integration of digital tools in supply chain coordination. For example, in Blitar, several farmer cooperatives interviewed during the data collection phase reported using basic digital communication (e.g., WhatsApp groups) to manage orders, but lacked systems for real-time inventory tracking or predictive analytics. Similarly, in Kendal, many farmers indicated limited access to affordable digital services and a heavy reliance on manual processes, even when handling fluctuating demand or feed prices.

5.1. The impact of digital transformation (DT) on operational supply chain (OSC) transparency

Digital transformation does not significantly impact operational supply chain transparency in the context of laying hen businesses in Indonesia. While farmers have begun adopting SMACIT technologies, their effect on operational supply chain transparency remains limited. This is primarily due to inadequate digital infrastructure, low technological literacy, and challenges in system integration among various supply chain stakeholders, resulting in suboptimal technology utilization. Big data analytics, despite its potential to facilitate the sharing of operational plans and strategic information among supply chain partners, is not fully leveraged in the laying hen industry. Limited human resource competencies in big data analytics technology hinder farmers from realizing its full benefits. For instance, many farmers are unable to utilize big data analytics effectively to enhance operational transparency, such as sharing real-time information on distributed products, stock levels, or supply and demand conditions.

Table 3
Validity Test (micro-scale).

Variable	Item	Loading (>0,5)	CA (>0,7)	CR (>0,7)	AVE (>0,5)
Digital Transformation			0792	0881	0715
	X1,1	0697			
	X1.2	0907			
	X1.3	0915			
Operational Supply Chain Transparency			0759	0861	0675
	Y1.1	0792			
	Y1.2	0853			
	Y1.3	0817			
Behavioral Intention to Adopt Big data analytics			0800	0861	0554
	Y2.1	0691			
	Y2.2	0706			
	Y2.3	0777			
	Y2.4	0697			
	Y2.5	0840			
Supply Chain Agility			0892	0921	0701
	Y3.1	0733			
	Y3.2	0795			
	Y3.3	0886			
	Y3.4	0873			
	Y3.5	0888			
Supply Chain Performance					
	Z1	0743	0881	0908	0589
	Z2	0815			
	Z3	0816			
	Z4	0844			
	Z5	0822			
	Z6	0683			
	Z7	0621			

As a result, while progress has been made in adopting digital technologies, their impact on operational supply chain transparency remains marginal. Concerted efforts from stakeholders are essential to improve technology management and promote more equitable adoption. This finding aligns with a study by J [94],. which highlights that although digital transformation holds the potential to simplify business operations and enhance visibility, many organizations struggle with low information accuracy and limited transparency. Furthermore, inconsistencies in information sharing can erode trust among supply chain partners, ultimately undermining transparency. The integration of digital technologies often encounters significant barriers, including high initial investment costs and complexities related to data security and interoperability [95]. These challenges impede businesses from fully optimizing digital transformation to support operational supply chain transparency.

5.2. The impact of digital transformation (DT) on behavioral intention (BI)

The results demonstrate that when egg-laying chicken farmers begin to adopt digital transformation (DT), their intention to integrate big data analytics increases. DT encompasses three critical phases: sensing, seizing, and transforming. I**n the sensing** phase, farmers adopting SMACIT technologies develop a better understanding of how to monitor their supply chains. This adoption helps reduce operational risks, such as feed price fluctuations and inefficiencies in distribution. Farmers who are more attuned to the advantages of digital technology are better prepared to mitigate risks in the egg-laying chicken business, which drives their intention to adopt big data analytics. Moreover, awareness of the operational efficiencies brought by digital technologies motivates farmers to further integrate advanced data-driven approaches into their businesses.

In the seizing stage, farmers recognize the tangible benefits of digital technology in creating flexible supply chain management systems. This flexibility allows them to respond quickly and effectively to market fluctuations in supply and demand. Increased responsiveness builds farmers' awareness of big data analytics's importance in minimizing oversupply—an issue that commonly disrupts the egg-laying chicken business in developing countries. Additionally, the adoption of digital technologies enables farmers to establish stronger external partnerships with customers and suppliers. Efficient communication through digital platforms ensures that egg distribution aligns with customer needs, further enhancing supply chain agility and responsiveness. **Meanwhile,** the transformation phase empowers farmers to make faster, more accurate decisions. Digital technology integration has proven to enhance business productivity, particularly in addressing challenges such as oversupply and insufficient communication with the market. As a result, the intention to adopt Big data analytics increases among business owners who recognize its potential to improve decision-making and operational performance.

This study aligns with a prior study by [96], which highlights the role of digital technology adoption in enabling data collection, analysis, and utilization throughout supply chain activities. The shift from traditional to modern agricultural practices allows farmers to manage resources more efficiently, adapt quickly to changes, and enhance operational capabilities. By undertaking DT, farmers can overcome issues of

Table 4
Hypothesis testing.

Hypothesis	Relationship	Std. Beta	Std. Error	t-value	p-values	Result
Direct effect						
H1	Digital transformation (DT)>>Operational supply chain transparency (OSC)	0126	0069	1832	0067	No
H2	Digital Transformation (DT)>> Behavioral Intention (BI)	0198	0077	2567	0010	Yes
H3	Digital Transformation (DT)>> Supply Chain Agility (SCA)	0220	0067	3267	0001	Yes
H4	Digital Transformation (DT) >> Supply Chain Performance (SCP)	−0030	0035	0853	0393	No
H5	Operational Supply Chain Transparency (OSC)>> Supply Chain Performance (SCP)	−0014	0046	0297	0767	No
H6	Behavioral Intention (BI) >> Supply Chain Performance (SCP)	0272	0044	6200	0000	Yes
H7	Supply chain agility (SCA) >> Supply Chain Performance (SCP)	0674	0057	11,716	0000	Yes
H8	Supply chain uncertainties (SCU)>>supply chain performance (SCP)	0101	0027	3814	0000	Yes
Indirect Effect						
H9	Digital Transformation (DT)>> Operational Supply chain transparency (OSC) >> supply chain performance (SCP)	−0002	0007	0255	0799	No
H10	Digital Transformation (DT)>> Behavioral Intention (BI) >> supply chain performance (SCP)	0054	0024	2263	0024	Yes (Fully mediation)
H11	Digital Transformation (DT)>> Supply chain agility (SCA) >> supply chain performance (SCP)	0148	0047	3119	0002	Yes (Fully mediation)

Note: * $p < 0.05$.

information asymmetry, reduce inefficiencies, and access broader markets [97,98]. Furthermore, digital transformation enables them to remain agile in navigating the evolving agricultural landscape, including responding to rapid decision-making demands to improve supply chain performance [99–101].

Despite its significance, this study is unique in addressing the relationship between DT and farmers' behavioral intention to adopt big data analytics, particularly in the context of egg-laying chicken businesses in developing countries. The findings underscore the critical role of government support in facilitating digital transformation, especially through investments in digital infrastructure. Improved infrastructure will empower small-scale farmers to adapt to technological advancements and respond effectively to the rapidly changing agricultural market landscape ([102]; Bolfe et al., 2020; Kamble et al., 2020).

5.3. The impact of digital transformation (DT) on supply chain agility (SCA)

This study also demonstrates that **Digital Transformation (DT)** positively impacts **Supply Chain Agility (SCA).** Farmers who adopt SMACIT technologies respond more effectively to business changes compared to those relying on traditional methods. **In the sensing** stage, farmers' heightened sensitivity to market dynamics—such as oversupply—enables them to react swiftly to changes in the laying hen business. By integrating digital technology, farmers can mitigate the risks of price drops and oversupply more effectively, stabilizing market conditions. In the seizing stage, farmers demonstrate improved risk mitigation capabilities and greater adaptability to fluctuations in supply and demand. The adoption of digital technologies enhances relationships with both suppliers and customers [60,103], enabling better communication and more responsive decision-making.

Meanwhile, the reconfiguration stage involves enhancing farmers' digital literacy to better align products with customer demand, reduce operational costs, and achieve greater distribution efficiency [104–106). This stage is particularly critical in the context of the VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) era, where rapid transitions are necessary. Small farmers, in particular, must adopt agile practices to respond to the uncertainties in the business environment and mitigate risks such as inflation in egg prices—a common issue in Indonesia.

When businesses reconfigure their supply chains, they significantly improve agility and resilience in navigating uncertainties [104–106]. This is supported by previous studies, which highlight the role of blockchain technology in increasing traceability and transparency within agricultural supply chains. Enhanced traceability facilitates quicker adjustments during disruptions, such as those caused by climate change or global pandemics, which can upend traditional supply chain models ([107]; R [108]).

5.4. The impact of digital transformation (DT) on supply chain performance (SCP)

This study found no conclusive evidence that Digital Transformation (DT) significantly impacts Supply Chain Performance (SCP) in the Indonesian laying hen business. Several factors contribute to this finding. Firstly, the industry is dominated by small-scale farmers with limited access to stable internet and often lack the digital skills necessary to leverage DT effectively. Many livestock businesses are located far from residential areas, further hindering access to reliable infrastructure. Moreover, the majority of farmers are approaching old age, limiting the availability of human resources skilled in the use of digital technology. Secondly, the market is highly sensitive to price fluctuations. This makes the substantial investment required for DT less appealing due to uncertainty about a commensurate return on investment. The large production costs associated with DT may not be easily offset by increased efficiency in the supply chain. Lastly, the laying hen industry is characterized by traditional practices, with a strong reliance on physical and logistical factors in areas like chicken maintenance and product distribution. These aspects are not easily influenced by digitalization alone.

This finding aligns with previous research that highlights the often-misinterpreted role of supply chain integration. While crucial for improved organizational performance, it is frequently viewed as a mere operational efficiency tool rather than a necessity [109]. Furthermore, the expected benefits of digitalization, such as enhanced visibility and responsiveness, may not fully materialize. This is evident in the findings by [110], which noted that despite high-quality information flow between stakeholders in the supply chain to support operational performance, the real impact on supply chain performance mediated by various capabilities remained suboptimal.

Additionally, the concept of supply chain resilience, often linked to dynamic capabilities, presents a complex picture. Previous research by [111] has shown that resilience has an indirect effect on SCP. These findings suggest that while organizations can develop capabilities to more quickly detect and respond to disruptions, realizing performance benefits requires integrating these capabilities with broader efforts toward sustainable business performance.

5.5. The impact of operational supply chain transparency (OSC) on supply chain performance (SCP)

This empirical study found no evidence that Operational Supply Chain (OSC) transparency has a significant impact on Supply Chain Performance (SCP). While big data analytics has the potential to revolutionize supply chain management by enabling real-time information sharing on product design, production plans, distribution, and delivery quality, its impact is limited in the context of the laying hen business in developing countries. Although transparency provided by big data analytics can improve operational visibility and responsiveness to market demand, several factors constrain its effectiveness, including limited infrastructure, market instability, and local regulatory constraints. In essence, while transparency can enhance information flow, uncontrolled external factors often become the primary obstacles to improving SCP.

The relationship between supply chain transparency and performance is not straightforward, especially in the context of strategic food commodities in developing countries. Kumar and Ganguly (2021) emphasize that information transparency can positively impact SCP by improving coordination and integration. However, this study also demonstrates that operational integration in supply chain activities tends to prioritize short-term coordination over long-term performance improvement (Kumar & Ganguly, 2021). This suggests that transparency alone may not be sufficient to achieve sustainable performance, particularly in complex supply chains where other factors such as agility and adaptability also play crucial roles [112]. Furthermore, supply chain complexity can hinder the effectiveness of transparency initiatives [113]. argue that supply chain complexity can interfere with decision-making and operational efficiency, ultimately reducing the potential benefits of transparency and making it difficult for businesses to realize ideal supply chain performance.

5.6. The impact of behavioural intention (BI) on supply chain performance (SCP)

This study demonstrates a positive correlation between the intention to adopt big data analytics or behavioral intention (BI) and improved Supply Chain Performance (SCP). Farmers can leverage BD to optimize supply chain management through deeper data analysis, encompassing egg demand forecasting, feedstock management, and livestock health monitoring. This enables faster and more accurate business decision-making, leading to reduced inefficiencies. The laying hen sector is characterized by sensitivity to cost and product

quality, the intention to adopt BD reflects businesses' recognition of the importance of technological innovation in addressing such market challenges and enhancing competitiveness.

[114] support this finding, demonstrating that integrating mobile-based communication technology increases farmers' intention to disseminate market information on agricultural commodities. This facilitates better decision-making and more effective coordination within the supply chain. Furthermore, supplier dynamics play a crucial role in shaping behavioral intentions. Research shows that irrational behavior from one member can negatively impact the performance of the entire supply chain [115]. Therefore, cultivating positive relationships and trust among stakeholders is paramount. For example, the "company--farmer integration" model emphasizes the importance of relationship management in ensuring high-quality, standardized output and effective supply chain integration [116].

5.7. The impact of supply chain agility (SCA) on supply chain performance (SCP)

This study demonstrates that Supply Chain Agility (SCA) has a positive effect on Supply Chain Performance (SCP). SCA plays a crucial role in improving SCP for laying hen businesses, particularly in developing countries. Big data analytics enables real-time monitoring and analysis of market demand, production, and distribution of laying hen egg products. This empowers farmers to adjust production in response to market dynamics. By utilizing big data analytics, farmers can predict fluctuations in egg demand, increase production and delivery efficiency, and diversify income by introducing new products. Additionally, big data analytics facilitates improved customer service through more accurate and faster information about product availability. SCA driven by big data analytics helps farmers mitigate the risk of oversupply [117] emphasizes that SCA, supported by visibility and collaboration, significantly enhances performance by enabling organizations to effectively meet stakeholder expectations. This responsiveness not only increases market share but also strengthens relationships with stakeholders, which is particularly important in agricultural businesses where trust and collaboration are key drivers of supply chain performance [118]

5.8. The role of supply chain uncertainties (SCU) in moderating digital transformation (DT) on supply chain performance (SCP)

This study demonstrates that Supply Chain Uncertainties (SCU) moderate the relationship between Digital Transformation (DT) and Supply Chain Performance (SCP). Uncertainties within the supply chain can hinder SCP, emphasizing the need for mitigation strategies. By leveraging big data analytics and predictive technologies, businesses can better anticipate demand patterns, price fluctuations, and changes in supplier availability. This enables farmers to design more appropriate strategies for adopting digital technologies such as SMACIT, which are known to enhance supply chain flexibility and efficiency.

Utilizing digital technologies empowers businesses to minimize risks, maximize decision-making accuracy, and optimize interactions with customers and suppliers. This can lead to reduced shipping costs, optimized inventory levels, and decreased oversupply risk in perishable commodities, ultimately creating a more responsive, transparent, and sustainable supply chain system [119]. highlight that uncertainty in supply chain management, often stemming from a lack of Information and Communication Technology (ICT), poses a significant threat to performance. Furthermore, low ICT development can increase the risk of data breaches and system failures, potentially disrupting the flow of information within business operations.

5.9. The role of operational supply chain transparency (OSC) in mediating digital transformation (DT) towards supply chain performance (SCP)

This study did not find evidence that Operational Supply Chain (OSC) mediates the relationship between Digital Transformation (DT) and Supply Chain Performance (SCP). Several factors contribute to this finding. Firstly, limited data availability hinders real-time decision-making and dynamic adaptation to market changes. Secondly, challenges related to digital infrastructure in developing countries pose significant obstacles. In the laying hen industry, digital technology can mitigate egg oversupply by facilitating more accurate demand management and optimizing distribution based on real-time data analysis. However, relying solely on operational transparency may not be sufficient to address rapidly changing market dynamics.

While transparency is often considered crucial for supporting DT and improving SCP, especially in the agricultural sector, the complexity of the agricultural supply chain presents significant challenges. The sector involves numerous stakeholders, including farmers, suppliers, processors, and retailers, each with unique interests and operational practices. This complexity can hinder effective information sharing and the achievement of transparency [120] emphasizes that operational integration and information sharing are critical for physical flow coordination, which directly impacts performance.

5.10. The role of digital behavioral intention (BI) in mediating digital transformation (DT) towards supply chain performance (SCP)

This study demonstrates that Business Intelligence (BI) fully mediates the relationship between Digital Transformation (DT) and Supply Chain Performance (SCP). BI acts as a key element in DT by revealing farmers' readiness and willingness to adopt digital technologies. In the context of livestock businesses in developing countries, increased BI fosters a tendency to implement digital technologies, accelerating the transformation process and directly improving SCP. This leads to reduced waste, improved distribution, and optimized production and delivery processes within the laying hen industry.

This finding aligns with [121], which highlights the increasing importance of studying the relationship between DT, BI, and SCP in the agricultural sector to support global food security. This mediation can be understood through theoretical frameworks like the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM), both of which emphasize the role of intention in predicting actual behavior. Furthermore, the agricultural sector faces numerous challenges, such as climate change and market volatility, necessitating a more resilient supply chain capable of adapting to unpredictable changes. These efforts not only enhance SCP but also contribute to the sustainability and resilience of agricultural businesses [122].

5.11. The role of supply chain agility (SCA) in mediating digital transformation (DT) towards supply chain performance (SCP)

This study demonstrates that Supply Chain Agility (SCA) fully mediates the relationship between Digital Transformation (DT) and Supply Chain Performance (SCP). SCA encourages businesses to adapt more readily to market changes, demand fluctuations, and external disruptions. Within the context of DT, the application of digital technologies, such as IoT and big data analytics, enhances visibility, facilitates flexible decision-making, and promotes efficient collaboration among supply chain actors.

Consequently, SCA strengthened by DT results in increased operational efficiency, reduced operational costs, and improved adaptability to changing consumer demands, ultimately enabling businesses to achieve better supply chain performance. Several international researchers have established that SCA is a dynamic capability that empowers companies to capitalize on opportunities and overcome threats in unstable

business environments ([123]; C.-J [124]). This capability is particularly crucial in the agricultural sector, where companies navigate complex networks involving suppliers, distributors, and customers. By increasing agility, companies can swiftly align their operational management with the demands of DT, leading to improved SCP [125–127].

6. PRACTICAL implications

This study provides several key implications for enhancing the effectiveness of digital transformation (DT) in Indonesia's laying hen industry, particularly among smallholder farmers. Despite the increasing adoption of digital tools, the impact on operational supply chain transparency (OSC) and supply chain performance (SCP) remains limited, pointing to structural, behavioral, and systemic barriers that must be addressed. First, the lack of significant impact of DT on OSC and SCP highlights the urgent need to strengthen rural digital infrastructure. Many farmers operate in areas with poor internet connectivity, limiting access to data platforms and digital tools. Public investment and public-private partnerships are essential to expand digital access, particularly in remote livestock-producing regions. Second, improving digital literacy and human capital is critical. The study finds that low technological skills especially among older farmers hinder the effective use of digital tools. Government and extension institutions should provide targeted training in basic digital skills, supply chain data interpretation, and risk management. Farmer organizations can play a central role in facilitating peer learning and hands-on training.

Third, the empirical results highlight that Behavioral Intention (BI) has a strong and significant influence on supply chain performance. This implies that beyond technical training, programs should also cultivate farmers' motivation and confidence to adopt digital tools. Success stories, demonstration projects, and farmer-to-farmer learning exchanges can enhance trust in digital transformation, thereby translating intention into real performance improvements. For instance, in Indonesia, programs such as Petani Milenial and Sekolah Tani, organized by agricultural agencies and universities, could be expanded to include livestock farmers by offering digital entrepreneurship mentoring and showcasing successful cooperative initiatives. Local government-supported pilot projects can further reinforce trust and accelerate adoption. Such an approach may also be adapted to other countries facing similar challenges in digital agricultural transformation.

Fourth, Supply Chain Agility (SCA) emerges as a critical determinant of performance, emphasizing the importance of implementing practical tools that strengthen responsiveness—such as real-time dashboards, predictive analytics, and adaptive logistics. Interventions focused on agility enable farmers to better manage oversupply, adapt to fluctuations in egg prices, and synchronize production with market demand. For instance, farmer groups and cooperatives could be provided with digital dashboards to track egg prices, predictive analytics to anticipate feed costs, and logistics platforms that directly link them with buyers and distributors. These instruments would empower smallholders to minimize excess production, align outputs more closely with market needs, and enhance overall competitiveness. Fifth, Supply Chain Uncertainties (SCU) play a major role in performance, underscoring the need for effective risk management. Policymakers and farmer groups should adopt measures such as forward contracts, cooperative buffer stocks, and insurance schemes to help farmers cope with volatile markets and rising input costs. At the farm level, scenario planning and predictive analytics can enhance preparedness for shocks. For instance, the Ministry of Agriculture could integrate digital forecasting tools into food security programs to stabilize egg supply and safeguard farmers' incomes during sudden market shocks.

Sixth, supportive policy frameworks are essential. Governments should provide incentives such as subsidies or digital technology grants for smallholders, while also addressing regulatory gaps related to data privacy, interoperability, and platform accessibility. Incorporating digital analytics into price stabilization and food security programs can also improve supply chain governance. Finally, the study underscores the importance of collaboration and trust. Developing digital platforms that facilitate transparent information sharing among supply chain actors including farmers, suppliers, and buyers will foster integration and resilience. Technologies such as blockchain and traceability systems can enhance coordination and reduce inefficiencies.

6.1. LIMITATION

This study has several limitations that warrant further research. First, the focus on two provinces in Indonesia may limit the generalizability of the findings. Future studies should consider a broader geographical scope to capture diverse farming practices and market conditions. Second, the study did not account for differences in structural ownership, which could influence technology adoption and supply chain dynamics. Future research could explore the role of family versus non-family businesses in moderating DT effects. Finally, the cross-sectional nature of the study does not capture the long-term impacts of DT on SCP. Longitudinal studies are recommended to assess the sustainability of these effects.

7. CONCLUSION

The study highlights the critical roles of BI and SCA in mediating the relationship between DT and SCP, while SCU acts as a significant moderator. These findings offer valuable insights for policymakers, practitioners, and researchers aiming to enhance supply chain resilience and performance in developing countries. By addressing the identified limitations and expanding the scope of future research, the potential of DT to revolutionize agricultural supply chains can be fully realized.

CRediT authorship contribution statement

Jaisy Aghniarahim Putritamara: Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Hery Toiba:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Funding acquisition, Conceptualization. **Tri Wahyu Nugroho:** Writing – original draft, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation. **Tina Sri Purwanti:** Writing – original draft, Software, Methodology, Investigation, Conceptualization. **Hari Dwi Utami:** Visualization, Supervision, Methodology, Investigation, Data curation. **Moh Shadiqur Rahman:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition. **Mochammad Syamsulhadi:** Writing – review & editing, Visualization, Validation, Project administration, Investigation. **Agus Nugroho:** Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation.

Declaration of competing interest

We, the undersigned authors, hereby declare that there are no known conflicts of interest associated with this publication, and there has been no financial support for this work that could have influenced its outcome.

Specifically, we declare that:

1. We are not currently employed, nor have we recently been employed, by any organization that may gain or lose financially through this publication.
2. We have not received consultancies, honoraria, or any form of paid expert testimony related to the content of this research.
3. We do not hold any stocks, shares, or ownership interests in companies or organizations that might be perceived to benefit from this publication.

4. We have not filed any patents, nor do we have any pending patent applications or registrations related to the subject matter of this study.
5. This research has not received funding from any sources that could be perceived to influence the interpretation or presentation of the findings.

All authors have contributed significantly to the research and writing of this manuscript and agree with its contents.

APPENDIX

QUESTIONNAIRE

LAYING HEN FARMERS' READINESS FOR DIGITAL TRANSFORMATION: DOES BIG DATA ANALYTICS ADOPTION MATTER FOR SUPPLY CHAIN PERFORMANCE IN INDONESIA?

Dear Respondent,

Assalamu'alaikum wr wb,

We are researchers from the Faculty of Animal Science and Faculty of Agriculture, Brawijaya University, currently conducting a Basic Research Grant project addressing the issue of egg over-supply in the poultry sector. We kindly request your participation in filling out this questionnaire to support our research. We assure you that your identity and responses will remain confidential and be used solely for research purposes.

Thank you for your valuable contribution.

Wassalamu'alaikum wr wb,

Respectfully,

Research Team

SECTION I: Responsent Idendtity

01. Name	[]
02. Phone nUmber	[]
03. Age	[] [] years
04. Gender	1. Male 2. Female
05. Source of Capital	1. Own capital 2. Formal financial institution 3. Informal financial institution
06. Years in layer farming business	[] years
07. Number of layer owned	[] heads: small: < 1.000 [] Medium: 1.000–10.000 [] Large: > 10.000 []
08. Education Level	· No schooling/Incomplete Primary · Primary School · Junior High School · Senior High School/Vocational · Diploma/Bachelor · Postgraduate
9. Number of Employees	……..person
10. Number of family members involved in the business	……..person
11. Is layer farming your main occupation	() Yes () No
12. Secondary Occupation	……
13. Human Resource involvement	1. Only nuclear family 2. Hired workers/professionals 3. Family members and hired workers
14. Business type	Family Business b. Non Family Business
15. Egg sales channel	a· Collectors b· Traditional markets c· Direct to consumers d· Direct to industry
16. Do you know when egg prices usually drop?	· Cannot predict · <3 times per year · >3 times per year
17. Losses due to egg price decline:	<100.000.000,- <100.000.000,–200.000.000 >200.000.000
18. Social media used to support business:	a. WhatsApp c. Instagram e others…… b. Facebook d. Telegram
19. Have you ever experienced bankruptcy in layer farming?	() Yes () No
20. Number of business failures due to egg price collapse: …….	
21. Do you wait to sell eggs until prices recover?	() Yes () No
22. Do you know egg supply sources from other regions?	a. · East Java b. · Central Java

(*continued on next page*)

(*continued*)

	c. · Outside Java d. · Other cities: …….
23. Do you think data on pullet/DOC distribution is important for PINSAR?	() Yes () No
24. Do you have data on egg distribution ready for sale?	() Yes () No
25. Do you know that layer eggs contribute to Indonesia's inflation?	() Yes () No
26. Do you have solutions to reduce egg price collapse?	() Yes….explain…. () No
27. Do you believe technology and information can help reduce egg price collapse?	() Yes….explain…. () No
28. Do you believe egg price fluctuations are caused by supply from outside regions?	() Yes () No
29. Marketing channels used:	a. · Farmer → Collector → Industry b. · Farmer → Consumer c. · Farmer → Collector → Modern Market d. · Farmer → Modern Market e. · Others: …….
30. Have you ever experienced chicken mortality due to climate change?	() Yes () No
31. Do you believe that layer farming will remain profitable in the future?	() Yes () No
32. If facing business difficulties, would you continue in this business?	() Yes () No
33. Do you believe past failures motivate you for greater success?	() Yes () No
34. Do you believe household welfare depends on egg price stability?	() Yes () No
35. Do you believe collaboration between universities, government, industry, and farmers can reduce business risks?	() Yes () No

II. Please rate the following statements on a scale from 1 to 5:
1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Measurement	*Score*				
	1	*2*	*3*	*4*	*5*
Digital Transformation (X) ([75]; Oubrahim et al., 2023; [77,78])					
I encourage new business processes by implementing SMACIT technologies (Social Media, Mobile devices, Analytics, Cloud, Internet of Things).					
I have started integrating digital technologies to transform my business.					
I increasingly rely on digital technologies in specific business activities.					
I believe adopting digital technology reduces supply chain risks.					
I believe adopting digital technology makes my supply chain more flexible.					
I use digital technologies to interact with customers.					
I use digital technologies to interact with suppliers.					
I believe the Internet helps me strengthen customer relationships.					
I believe digital technologies enable me to adjust products to customer demand.					
Operational Supply Chain Tranparency (Y1)					
([112])					
I believe that big data analytics helps us in sharing operational plans (e.g., distribution plans, production plans) related to product design information among supply chain partners.					
I believe that big data analytics helps us in sharing operational information (e.g., quantity of products distributed, process, delivery quality, stock) among supply chain partners.					
I believe that big data analytics helps us in sharing strategic information (e.g., new orders, product demand, internal and external conditions or supply and demand and government regulations)					
Behavioural Intention to Adopt Big Data Analysis (Y3) ([46,81,112])					
I intend to adopt big data analytics in my business					
I intend to use big data analytics in the future					
I also recommend big data analytics to be used by the government and companies so that we can coordinate well					
I intend to use big data analytics to support egg supply chain activities					
I intend to change supply chain operations and management with big data analytics					
Supply Chain Agility (Y2)					
([79,112]))					
I believe that big data analytics helps me to be efficient in production time until delivery to consumers					
I believe that big data analytics helps me to introduce new products other than chicken eggs					
I believe that big data analytics can improve my ability in product delivery.					
Big data analytics helps me to improve customer service					
Big data analytics helps me to adapt to market changes for chicken eggs					

(*continued on next page*)

(*continued*)

Measurement	*Score*				
	1	*2*	*3*	*4*	*5*
Supply Chain Performance (Z) [82–84]					
The logistics cost of broiler eggs tends to be low					
We have achieved profits					
We have egg products					
Many of our customers are satisfied					
Our egg delivery process is on time					
We respond quickly to changes in consumer demand					
We are able to efficiently respond to market price fluctuations for broiler egg products					
Supply Chain Uncertainties (a) [83,85,86]					
Our business is highly dependent on suppliers to carry out the production process					
I am able to predict egg demand patterns					
I am able to estimate changes in egg prices					
I am able to estimate egg deliveries on time					
I know the exact number of egg suppliers					

Data availability

Data will be made available on request.

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