

DIGITAL TRACEABILITY AND PSYCHOLOGICAL EMPOWERMENT AS DRIVERS OF FARMER BARGAINING POWER AND FOOD SUPPLY CHAIN RESILIENCE IN EMERGING AGRIBUSINESS MARKETS

HOU TIANJIAO¹, ERMI GIRSANG^{2*}, CLARISSA LISTER³

¹⁻³DEPARTMENT OF ECONOMICS, PRIMA INDONESIA UNIVERSITY

*Corresponding Author's Email: ermigirsang@unprimdn.ac.id

ABSTRACT

The article presents a secondary review of the influence of digital traceability and psychological empowerment on the formation of sources of power, such as bargaining power among farmers, and on the resilience of food supply chains in emerging agribusiness markets. It has a selectively split evidence design. Only the review and theory articles are dedicated to developing the conceptual lens. In contrast, the results are based on 20 main empirical studies on traceability systems, blockchain, Internet of Things adoption, e-commerce, smart farming, contract farming, and the resilience of the digital economy. The thematic analysis reveals that traceability can reinforce bargaining power by transforming product origin, product quality, and transaction records into reliable information that farmers can use to negotiate. Nevertheless, digital records rarely alter the power balance. This is advantageous to farmers when systems enhance competence, perceived control, channel choice, and confidence in entering into contracts, cooperatives, direct sales, or premium markets. Powerful ones comprise surveys of large farms, panel data, structural equation modelling or case evidence, but numerous studies are cross-sectional, intention-based, China-centred and weakly causal in identification. The review concludes that traceability is not a disinterested technical solution. Under inclusive institutional circumstances, it can facilitate visibility, market access, and resilience. Under imbalanced terms, it may exacerbate compliance expenses and supplier monitoring.

KEYWORDS: digital traceability, psychological empowerment, farmer bargaining power, food supply chain resilience, emerging markets, agribusiness management

INTRODUCTION

The world's food systems are under pressure on multiple fronts due to high prices, climate shocks, limited digital capacity and concentrated supply chains. Urgent is not abstract. The 2025 State of Food Security and Nutrition in the World showed that moderate or severe food insecurity in 2024 concerned 28.0% of the global population, or a little over 2.3 billion people, and it is still 335 million more people than it was before the COVID-19 pandemic (FAO, IFAD, UNICEF, WFP, and WHO, 2025). Small farms are strategically significant at the production end. The farmers (FAO found that, of the six farms, five are less than two hectares, use about 12 percent of the land, yet yield approximately 35 percent of the world's food) (FAO, 2021). For least developed countries, the share of agriculture, forestry, and fishing in GDP is 19.9% in 2024 (World Bank, 2025). These statistics pose the article's overall managerial dilemma: farmers are key to food security, but most have weak bargaining power, limited market information, and limited shock-absorbing capacity.

A solution is increasingly suggested for digital traceability. A QR code can also be used to log what was manufactured, how it was manufactured, which materials were handled by product users, where it traveled, etc. QR codes can also be used to record e-commerce transactions, blockchain registries, Internet of Things sensors, and digital certificates. Theoretically, these instruments decrease the information asymmetry among farmers, buyers, processors, regulators and customers. They are also useful for fast recall, quality control and meeting food safety or sustainability standards. Nonetheless, the same systems may potentially be expensive compliance tools when the farmers provide data without obtaining price, channel, or risk control. Traceability can thus serve to empower producers or strengthen buyers' power.

The article argues that the missing mechanism is psychological empowerment. The presence of data does not mean that farmers will not bargain. They negotiate in case digital systems make them feel more competent, in control, and confident. A farmer who is aware of traceability requirements, believes in the system, perceives economic benefits, and has buyer options is in a better bargaining position than a farmer who scans the code to an intermediary. The query

thus posed in the article is: what is the joint influence of digital traceability and psychological empowerment on farmers' bargaining power and the resilience of food supply chains in emerging agribusiness markets? The working model, on which the review is guided, is illustrated in Figure 1.

This interest in new agribusiness markets is intentional. These markets tend to be characterized by large smallholder engagement, rapid platform growth, spotty regulation, lumpy infrastructure, and robust intermediaries. These circumstances render digital traceability appealing since it delivers a sense of stability and access to the market, yet dangerous, as the costs of compliance might fall on farmkeepers. The critical review should thus question the owner(s) of the data, who certifies the records, who covers the hardware and the certification, and who receives the premium. In the absence of these questions, digital traceability might be equated with empowerment, even though farmers remain price takers.

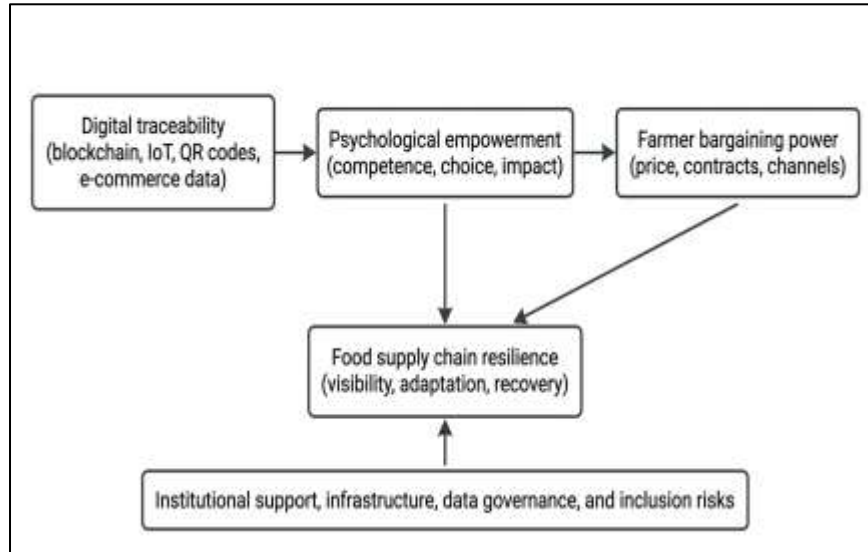


Figure 1. Conceptual model linking digital traceability, psychological empowerment, farmer bargaining power, and food supply chain resilience.

LITERATURE REVIEW AND THEORETICAL LENS

The literature review comprises secondary and theoretical literature. This distinction is necessary because the findings section should be dedicated to the primary empirical studies, as specified by the paper's structure. Review scholarship specifies traceability as not a technical tracking facility. According to Aung and Chang (2014), food traceability is a system for ensuring safety, quality, and consumer trust in which information regarding production, processing, distribution, and retail is linked. Review of blockchain further develops this argument by indicating that proving provenance data based on immutable or shared ledgers can be more credible; however, they also note that most blockchain projects are still in their early stages and predominantly fragmented and susceptible to flawed input data (Kamilaris et al., 2019; Xu et al., 2020). This implies that the quality of traceability is due not only to technology but also to governance, incentives and verification.

Psychological empowerment theory introduces a Farmer-centred prism. Spreitzer (1995) theorises empowerment in terms of meaning, competence, self-determination, and impact. When applied to the agribusiness, this indicates that farmers must perceive digital traceability as important to their business, feel capable of utilizing it, maintain some control over their involvement, and believe that their activity has a market impact. The technology acceptance theory endorses this reasoning. Davis (1989) believes that adoption is influenced by perceived usefulness and perceived ease of use. The theory of planned behaviour includes the attitudes, subjective norms and perceived behavioural control (Ajzen, 1991). According to these theories, farmers are expected to participate when the system is helpful, practicable, socially approved, and aligned with their perceived control.

The resource dependence theory and supply chain resilience theory sharpen the power argument. Resource dependence theory is a concept that describes how resource-dependent actors may be influenced by actors with scarce resources, access to markets, access to information or certification power (Pfeffer & Salancik, 1978). Digital traceability can reduce reliance by providing farmers with portable data on quality and provenance. Still, it can heighten reliance insofar as the platform proprietor controls the standards and is allowed to monopolise the information. The resilience theory focuses on observation, redundancy, collaborations, adjustment, and recovery following a disruption (Christopher & Peck, 2004). Traceability, in this opinion, helps resilience only when information can be acted upon

and shared throughout the chain. UNDP (2021) also advises that agri-food traceability should be inclusive, scalable and sustainable to avoid excluding small-scale producers.

An important gap is still there. The tools of transparency or secondary reviews frequently hail concepts such as traceability, blockchain and digital agriculture and theories of empowerment highlight the agency of farmers. Fewer papers are bridging the two sides. This review thus considers digital traceability a technical infrastructure and psychological empowerment the mechanism for changing behaviour, turning information into bargaining power and resistance.

METHOD

The research paper adheres to a secondary review design and thematic analysis. The lens is developed in the literature review through secondary reviews and foundational theories. The findings are based only on primary empirical studies. The division prevents circular reasoning, whereby a review paper is initially used to define the field and then addressed again as evidence. Peer-reviewed articles published since 2017 and focusing on the topics of digital traceability, blockchain, IoT, e-commerce, digital empowerment, contract farming, marketing channels or the consequences of the digital economy on agricultural or food supply chains were considered search priorities. Among the studies, those that reported original empirical data, including farm surveys, interviews, case studies, panel data, expert judgements, structural equation modelling, treatment effect models or econometric estimations, were kept.

There were twenty major studies coded. The idea of coding was deductive and inductive. Deductive codes were based on the conceptual model: traceability, empowerment, bargaining power, and resilience. Recurring barriers added via inductive coding included infrastructure gaps, skill deficits, platform ownership, and scale bias. Method, sample, context and limitations were also coded in each study. Figure 2 summarizes the thematic distribution, and Figure 3 summarizes the methodological profile. Table 1 outlines the main studies that informed the findings. The results did not consider any paper utilized in the literature review.

Quality appraisal revolved around three issues. First, the review determined whether the study measured actual behaviour as adoption, channel choice, contract participation, income, or resilience, and not intention alone. Second, it examined whether the approach addressed selection bias, common method bias, or unobserved heterogeneity. Third, it accounted for the possibility that the sample comprised vulnerable smallholders or primarily better-endowed farmers. The significance of this appraisal is that the unequal effects may be concealed in a technologically favorable outcome. As an illustration, a traceability programme can boost overall incomes and exclude those without smartphones, literacy, transport, or certification capital. The results are thus perceived as conditional evidence rather than impartial evidence that digitalisation will necessarily empower farmers.

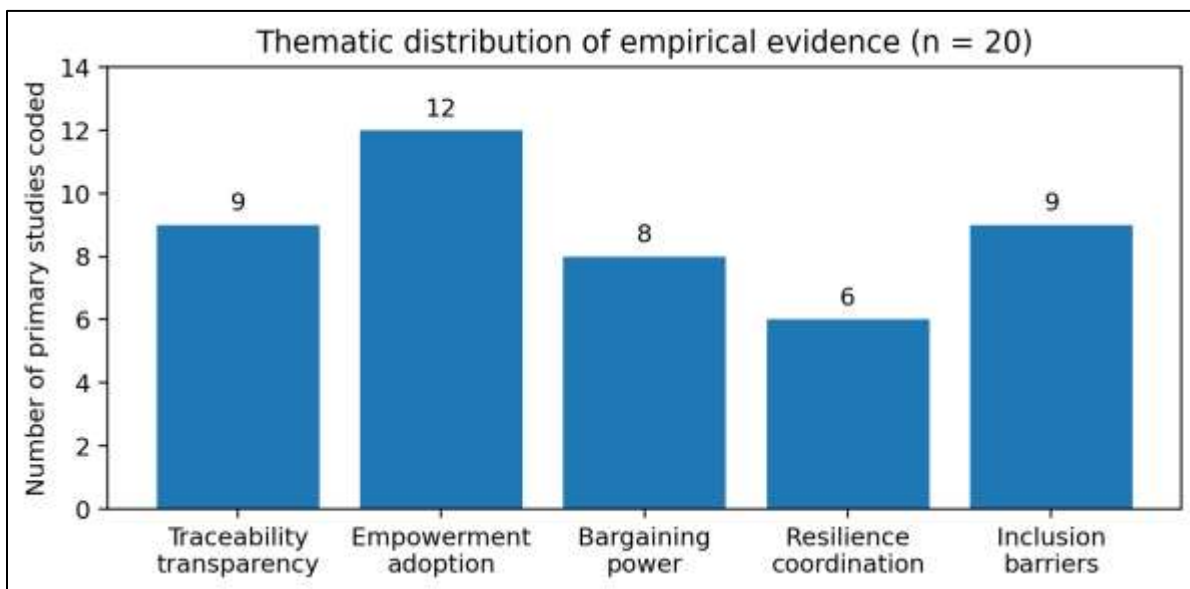


Figure 2. Thematic distribution of the 20 primary empirical studies coded for the findings.

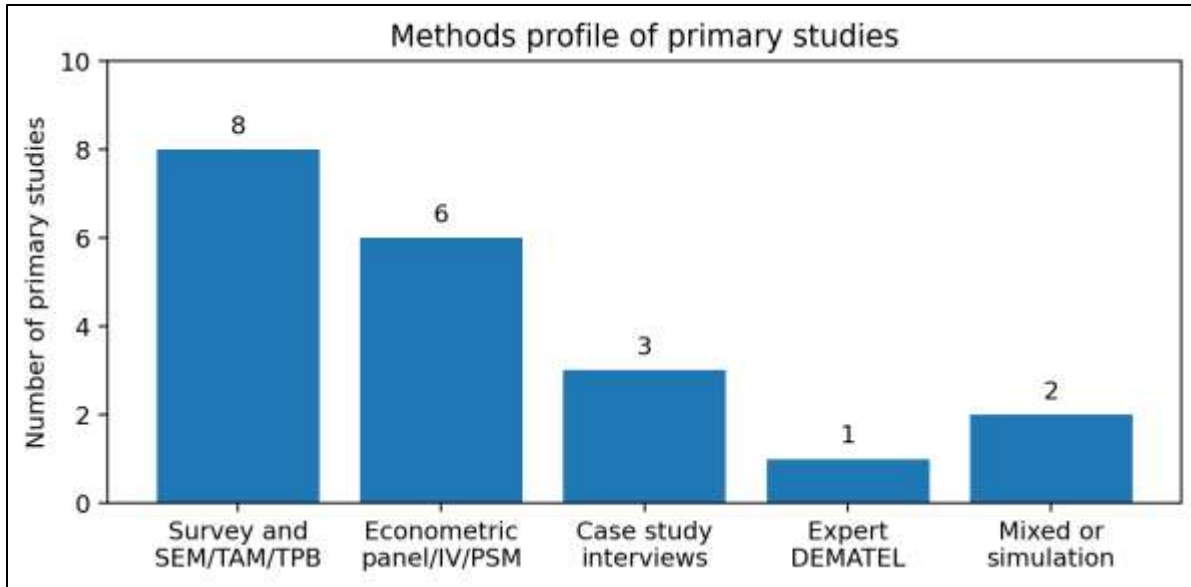


Figure 3. Methods profile of the primary empirical studies. The dominance of surveys and econometric models shapes how cautiously findings should be interpreted.

Table 1: Primary empirical studies used in the findings

Study	Context and method	Relevant finding	Method critique and theme
Huang & Fu (2023a)	410 apple farmers in Henan, China; SEM, ANN, and NCA.	Perceived usefulness dominated intention to participate in traceability; policy support and moral norms mattered.	Strong multi-method design, but cross-sectional and intention-based.
Huang & Fu (2023b)	408 fruit farmers in Henan, China; SEM and system dynamics.	Attitudes, perceived control, subjective norms, moral norms, and safety awareness shaped willingness.	Good behavioural model, but regional- and crop-specific.
He et al. (2023)	197 users of a navel orange traceability system, PLS.	Satisfaction, habits, and perceived value supported continuous use.	Captures actual users, but with a small sample and a single system.
Li et al. (2024)	357 farmers in Jiangxi, China; UTAUT and TOE SEM.	Government support, complexity, compatibility, and innovativeness influenced IoT adoption.	Useful integration of technology and environment, but limited generalisation.
Sun et al. (2021)	264 pig farmers in Shaanxi, China; UTAUT.	Performance expectancy, effort expectancy, social influence, innovation, and risk influenced the adoption of IoT traceability.	Clear model, but self-reported willingness may overstate actual adoption.
Pappa et al. (2018).	Greek dairy supply chain; PLS-SEM.	Acceptance of electronic traceability depended on technology attitudes and planned behaviour factors.	Adds processors and farmers, but sector-specific.
Vinholis et al. (2017)	84 cattle farmers in Brazil; binomial logit.	Scale, access to information, and human/social capital increased the adoption of beef traceability.	Small sample, but it directly measures adoption.
Zhang et al. (2025)	577 rural farmers in China; Probit and mechanism tests.	Digital capabilities promoted direct or cooperative channels through networks, risk attitudes, and bargaining power.	Strong channel focus, but causality remains constrained.

Yang et al. (2026)	1,370 grape growers in Liaoning, China; Logit, CMP, Oster tests.	Digital empowerment increased willingness and behaviour in contract farming, especially for larger farms.	Large-sample and robustness checks, but the inclusion gap remains.
Yin et al. (2025).	Rural China survey; endogenous switching regression.	E-commerce participation increased income through channels, transaction cost reduction, and value enhancement.	Addresses selection better than simple regressions, yet instruments require caution.
Qiu et al. (2024)	704 Jiangsu farm households tracked from 2020 to 2022; fixed effects, PSM, IVProbit.	E-commerce operations promoted green technology adoption.	Panel design strengthens inference, but province-specific context remains.
Yang et al. (2024)	2,825 grain farmers from the China Rural Revitalization Survey; treatment effect and mediation models.	Digital economy participation increased ecological agricultural technology adoption.	Large sample, but proxy measures of digital participation are broad.
Ding et al. (2025)	Chinese provincial data, 2008-2023; fixed effects, mediation, threshold models.	The digital economy enhanced the resilience of the food supply chain by adopting information technology and establishing fiscal thresholds.	Useful system-level evidence, but not farm-level empowerment.
Zhu et al. (2024).	Chinese panel data: analysis of resilience and industrial agglomeration.	The digital economy strengthened food system resilience through agglomeration.	Macro evidence, but farmer bargaining remains indirect.
Compagnucci et al. (2022)	Two small-firm blockchain case studies; interviews and interdisciplinary analysis.	Blockchain improved stakeholder interaction and market signalling but faced economic and technical barriers.	Rich process evidence, limited external validity.
Rogerson & Parry (2020).	Food company blockchain case studies; semi-structured interviews.	Blockchain improved supply chain visibility, with consumers willing to pay premium costs.	Strong visibility insight, but firm rather than farmer perspective.
Shao et al. (2025)	Tanzanian agricultural supply chains: empirical analysis of power asymmetries.	Blockchain adoption was shaped by buyer-farmer dependence on power and market access constraints.	Directly addresses power, but technology diffusion remains in its early stages.
Elkoraichi et al. (2025).	African agri-food blockchain barriers: expert DEMATEL.	Regulation, infrastructure, and reliable data were key causal barriers.	Expert evidence is useful, but barrier lists can reflect prior assumptions.
Doanh et al. (2022).	Vietnam tea farmers: TAM and barriers.	Livestream sales intention was influenced by perceived usefulness and barriers.	Relevant to a digital market agency, but not traceability specific.
Diaz et al. (2021).	Bamboo producers: mobile marketing app adoption study.	Mobile market tools depended on perceived usefulness and adoption constraints.	Useful for market access, but the commodity niche is narrow.

FINDINGS: THEMATIC ANALYSIS OF PRIMARY STUDIES

Traceability Adoption Drivers

Digital traceability generates value when it transforms farm practices into plausible market information. Primary traceability research has consistently indicated that adoption is based on farmers' survey responses about whether traceability will positively influence market outcomes. Huang and Fu (2023a) identified perceived usefulness as the

most potent factor influencing apple farmers' participation in traceability, and He et al. (2023) identified satisfaction, habit, and perceived value as factors facilitating users' continued use of the traceability system. The study by Sun et al. (2021) also demonstrated that performance expectancy, effort expectancy, social influence, personal innovation, and perceived risk are determinants of pig farmers' willingness to use IoT traceability. These findings differ from strictly technical assertions that uptake of traceability takes an automatic step-off after food safety returns. Traceability is an economic and behavioural offer to farmers, rather than a compliance-only mechanism.

The dichotomy between studies is significant. Pappa et al. (2018) found that eTraceability acceptance within the Greek dairy chain was mediated by technology acceptance and planned behaviour, and Vinholis et al. (2017) demonstrated that scale, specialised information, and human and social capital were relevant to cattle traceability adoption in Brazil. Psychological preparedness and structural capacity are interrelated. A smallholder may be aware of the benefits of traceability but lack the money, education, access to buyers, and administrative capacity. This is the reason why traceability programs are sometimes more beneficial to more connected farmers.

Digital Empowerment and Farmer Agency

Psychological empowerment is the connection between information and bargaining power. The original research demonstrates consistent support for perceived usefulness, perceived behavioural control, competence, habit, and social support. Huang and Fu (2023b) found that willingness to be traced was influenced by attitudes, perceived behavioural control, subjective norms, moral norms, and safety awareness. Li and colleagues (2024) furthered this trend to implement the market of the IoT by demonstrating that complexity, compatibility, government support, interactiveness and innovativeness of farmers had a role to play. Equally, Diaz et al. (2021) and Doanh et al. (2022) demonstrated that usefulness and perceived barriers influenced farmers to engage with mobile marketing tools or livestream sales. The implications of these findings are that empowerment cannot be a soft add-on. It is the behavioural status that distinguishes the strategic use of digital tools from their non-strategic use.

Nonetheless, the body of proof of empowerment is not even in terms of its methodology. Cross-sectional surveys, which most behavioural studies employ, are great in gauging perceptions but do not do a good job of proving that digital systems empowered them. They are also based on self-reported willingness, which might be inflated by social desirability bias, policy pressure or interviewer effects. The more robust designs are a triangulation of models or an actual behaviour. In one instance, Yang et al. (2026) employed a large sample of grape growers and robustness checks to demonstrate that digital empowerment positively influenced willingness and behaviour in contract farming. Nevertheless, the study found that larger farmers were more likely to be affected by their behaviour, implying that empowerment could be unbalanced in situations where capital, literacy or scale is essential to reap the benefits of digitality.

Market Access and Bargaining Power

Dedicating channels, diversifying channels and quality evidence characterized by credibility enhance bargaining power. Zhang et al. (2025) discovered that digital capabilities minimized reliance on wholesalers and facilitated cooperative and direct sales channels through social networks, risk attitudes, and bargaining power. Yin et al. (2025) discovered that the income of rural farmers through e-commerce involvement was enhanced by their ability to sell their produce in more ways, reduced transaction costs and maximized the value of their products. Improved knowledge: Doanh et al. (2022) discovered that when perceived usefulness exceeded barriers to adoption, livestream sales could emerge as a potential market participation channel for tea farmers. These papers demonstrate that bargaining is transformed under digital empowerment due to the expansion of alternatives. With traceability data, a farmer that has a single buyer is still dependent. Quality, origin, and consumer trust are among the negotiation assets that a farmer can demonstrate in a digital record and leverage across multiple channels.

Digitalisation and Supply Chain Resilience

The resilience benefits are strong at the system level but less so at the farm level. Ding et al. (2025) found that the digital economy enhanced resilience in the Chinese food supply chain through the adoption of information technology as a mediator and fiscal investment as a threshold condition. Similarly, Zhu et al. (2024) established that the digital economy enhanced the resilience of China's food system, in part due to industrial agglomeration. Qiu et al. (2024) demonstrated that green production technology could be promoted through the use of e-commerce, and Yang et al. (2024) revealed that farmers' involvement in the digital economy enhanced the adoption of ecological agricultural technology. These works imply that digitalisation facilitates resilience through information mobility, the dissemination of innovations, clean production, and market accessibility.

The macro- and farm-level results are not exactly consistent, however. Indicators of provincial or national digital economy cannot indicate whether smallholders acquire bargaining power. This restriction is pointed out in case studies. In their study, Compagnucci et al. (2022) found that blockchain could enhance stakeholder engagement and the reputation of small agri-food companies. However, poor scaling was due to technical and economic challenges. Rogerson and Parry (2020) discovered that blockchain enhances visibility within food supply chains at scale, with end

consumers willing to pay for trusted products. Shao et al. (2025) more directly demonstrated that power asymmetries in Tanzanian agricultural chains influence blockchain diffusion. As such, resilience is not merely a product of digital infrastructure. It is a government deliverable.

Inclusion Barriers and Power Asymmetry

Elkoraichi et al. (2025) identified blockchain regulation, infrastructure, and trust in data as the main obstacles to its adoption in African agri-food chains. Vinholis et al. (2017) demonstrated that capital-intensive systems and access to information affected the acceptance of traceability in Brazil. Li et al. (2024) concluded that complexity was a barrier to increasing IoT uptake, and Sun et al. (2021) concluded that perceived risk was a factor. These outcomes lead to the same conclusion: digital trace goals may pose a barrier to entry, as farmers will have to pay for equipment, meet data demands, manage apps, and meet criteria unless better market incentives are provided. When buyers or platforms control data, farmers may comply with transparency requirements but remain disempowered.

Within the themes, there is also the influence of the methods on the credibility of claims. Using survey-based SEM studies is a good idea, as they can identify psychological pathways. Still, they cannot completely isolate beliefs, policy pressures and the actual gains of a given economy. The causal approach of econometric analysis with panel, treatment-effect, PSM, IV, or switching regression models is better positioned to approximate causality. Still, it tends to aggregate digital participation into a broad factor and fails to capture farmers' experience controlling the data. The case studies provide organisational detail and platform politics, but they cannot typically estimate average effects. Expert DEMATEL can be useful for prioritizing barriers, but it requires expert selection and a starting list of barriers. Combining the diverse approaches is thus more convincing than any single study. The review concludes that there is consistent evidence showing that digital tools could assist, but conditional evidence that they empower the weakest farmers.

DISCUSSION

The results generally support the technology acceptance theory but also outline its limitations. The logic of perceived usefulness and ease of use, as proposed by Davis (1989), can be observed in the areas of traceability, IoT, mobile marketing, livestream sales, and smart farming research (Diaz et al., 2021; He et al., 2023; Huang & Fu, 2023a; Pappa et al., 2018; Sun et al., 2021). When technologies are more likely to result in better market presence, lower transaction costs or easier compliance, there is a higher likelihood that farmers will adopt these technologies. Nevertheless, power may need to be underestimated according to the technology acceptance theory. A system can benefit the buyer and be a burden to the farmer. In this way, usefulness needs to be actor disaggregated. In the case of farmers, usefulness ought to be considered in terms of better prices, reduced risk, greater buyer preference, or greater autonomy, rather than willingness to participate.

The theory of planned behaviour is also consistent with evidence, particularly in research showing that attitudes, subjective norms, moral norms, and perceived behavioural control influence willingness (Huang & Fu, 2023b; Pappa et al., 2018). Nevertheless, the analogy of infrastructure and barrier research indicates that the perceived control is a partially material aspect. A farmer might not feel in control when there is a lack of connectivity, affordability, training, and buyer appreciation for traceable quality (Elkoraichi et al., 2025; Li et al., 2024; Vinholis et al., 2017). It implies that TPB cannot be seen in isolation from institutional capacity but rather as an addition to it.

There is no better explanation of the process by which digital tools become bargaining assets than psychological strength theory. The dimensions of meaning, competence, self-determination, and impact in Spreitzer's (1995) map fit well with the empirical themes. Value comes in where traceability relates to food safety, premiums, contracts, or reputation. Competence manifests in farmers' ability to comprehend and work with systems. Self-determination manifests in direct or cooperative selling, or in selecting the contract through digital channels. Impact refers to changes in price, income or resilience outcomes resulting from digital involvement (Yin et al., 2025; Zhang et al., 2025). The drawback is that most studies do not directly measure empowerment, but rather adoption intention. Future studies ought to quantify how farmers experience greater negotiating power, greater ability to reject unjust purchasers, or greater control over quality premiums following the adoption of traceability.

The most critical one is dependence on resources, as described by resource dependence theory. Digital traceability will reduce information asymmetry, but it does not necessarily reduce dependency. When a farmer relies on a portable, trusted and farmer-accessible traceability record, information can reduce reliance on an intermediary. The same is demonstrated by Zhang et al. (2025), in which digital capabilities changed farmers' direct and collaborative channels. Traceability can make more people reliant if the platform is owned by a powerful buyer who dictates a standard and can see the data. Shao et al. (2025) reveal this issue in Tanzanian supply chains, in which power imbalances shape the diffusion of technology and access to markets. Blockchain, or IoT, is not inherently powering, then. Bargaining outcome is rooted in data ownership, platform terms, contract drafting, and conflict resolution.

The resilience results should also be properly interpreted. Ding et al. (2025) and Zhu et al. (2024) present compelling system-level evidence that the digital economy can enhance the resilience of the food supply chain. However, it is the infrastructure, the adoption of information technologies, fiscal investment and agglomeration, but not necessarily the

empowerment of farmers. Farm-scale analyses reveal that adapting to resilience requires both adaptive capacity and market incentives. According to Comagnucci et al. (2022) and Rogerson and Parry (2020), visibility aids coordination and trust, whereas scaling depends on cost, consumer willingness to pay, and interoperability. The current review thus narrows down resilience theory, contending that visibility is warranted yet inadequate. Inclusive resilience involves both visibility and farmer agency.

A compare-and-contrast analysis of the overall literature and findings results in a balanced conclusion. Secondary reviews are correct that traceability would enhance transparency, food safety, ability to recall, and consumer trust (Aung & Chang, 2014; Kamilaris et al., 2019). The first piece of evidence would be that these benefits are not evenly distributed among farmers. Adoption is high when visible usefulness, simple systems, credible policy support and open digital participation provide real market alternatives. Highest adoption occurs when the cost, complexity, inter-infrastructure gaps and power asymmetry are not overcome. This means that traceability, as an empowerment architecture (not a simple installation), is the managerial priority.

CONCLUSION AND IMPLICATIONS

This article reviewed the roles of digital traceability and psychological empowerment as drivers of farmers' bargaining power and resilience in food supply chains in new agribusiness markets. The evidence demonstrates that traceability is valuable when it produces credible, usable, and portable information about product origin, quality, and exchanges. It is enabling when farmers can use that information to secure contracts, cooperatives, direct sales, e-commerce, premiums or safer long-term commitments. When the same information is used to enable coordination, risk visibility, adaptation and recovery throughout the chain, it becomes resilient.

Three implications follow. Firstly, managers of agribusinesses need to access traceability information as a cooperative resource, rather than as a buyer's compliance document. The farmers must be able to access their own data and have the freedom to utilize it with buyers and across platforms. Second, governments and development agencies must finance not just hardware and platforms but also training, extension services, rural connectivity, data standards, and dispute resolution. Third, scholars ought to go beyond their intention to adopt and challenge the view that digital traceability alters prices, contract terms, income stability and recovery following disruption. Digital traceability versus farmer empowerment is the least promising of the agendas. It is online traceability to empower farmers.

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