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Beyond Channel Expansion: Comparative Effects of E-commerce Participation on Production Standardization, Marketing Diversification, and Green Technology Adoption among Grape Growers

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Abstract

Using survey data from 386 grape growers in Yingkou City, this article examines whether e-commerce participation affects three distinct domains of growers' behavioural upgrading: standardized production, diversified marketing, and green technology adoption. Unlike studies that treat behavioural change as a single aggregate outcome, this paper compares the relative sensitivity of each domain and discusses why different behavioural responses emerge under the same digital market condition. A regression framework based on the dissertation dataset shows that e-commerce participation exerts significant positive effects on all three outcomes, with the strongest direct effect observed for diversified marketing behaviour (0.465), followed by standardized production behaviour (0.428) and green technology adoption behaviour (0.412). Mechanism evidence indicates that information acquisition capability works as a positive transmission channel, while risk perception introduces a countervailing restraint effect. The comparison of moderator coefficients further suggests that marketing behaviour is the most elastic behavioural domain: it is more strongly weakened by household-head age and more strongly reinforced by planting scale and household human capital than the other two outcomes. These findings imply that the digital transformation of specialty agriculture should not be evaluated only by whether farmers sell online; rather, it should be assessed in terms of which business functions are upgraded first, which require stronger capability support, and which groups can convert e-commerce participation into stable behavioural change more effectively.

Keywords

E-commerce participation; grape growers; production standardization; diversified marketing; green technology adoption.

1. Introduction

Research on rural e-commerce has moved beyond asking whether online participation can expand sales channels and has increasingly turned to the question of whether digital participation changes farmers' operating logic. For fresh agricultural products such as grapes, platform participation is closely linked not only to transactions but also to product grading, packaging, customer communication, reputation management, and the adoption of more stable production practices. Nevertheless, behavioural upgrading is not a single process. Some growers may use e-commerce mainly to diversify sales channels, whereas others may gradually adjust field management, post-harvest handling, or green input choices. A comparative perspective is therefore needed to determine which behavioural domain responds most strongly to e-commerce participation.[1]

This article takes Yingkou grape growers as the empirical object and compares the direct and relative behavioural effects of e-commerce participation on standardized production behaviour,

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diversified marketing behaviour, and green technology adoption behaviour. The purpose is not merely to show that e-commerce is beneficial, but to identify the differential elasticity of these three outcomes and to clarify what this means for digital agricultural upgrading in specialty-fruit regions.[2]

A comparative design matters because the three outcomes examined here are not interchangeable. Standardized production behaviour concerns compliance with stable cultivation, grading, and post-harvest norms; diversified marketing behaviour reflects the reallocation of market channels and customer contact; green technology adoption behaviour concerns longer-cycle changes in input use and production methods. Treating them as a single composite index can conceal an important empirical question: does e-commerce first reshape how farmers sell, how they produce, or how they invest in sustainability? For specialty fruits, this sequence is especially relevant because perishability, visual quality, and reputation transmission make market response unusually fast, whereas technical adjustment often unfolds more slowly. The comparison therefore helps clarify the internal order of behavioural transformation rather than merely confirming that transformation exists.

2. Analytical Perspective and Research Expectations

The behavioural effects of e-commerce participation can be understood through a capability-and-constraint perspective. On the capability side, online participation broadens access to market information, product-presentation knowledge, platform rules, and peer learning, thereby lowering information asymmetry and enabling farmers to respond more rapidly to market signals. On the constraint side, online participation also exposes growers to rating pressure, return risk, logistics uncertainty, and greater visibility of product defects. As a result, different behavioural domains may not respond equally. Diversified marketing behaviour is expected to change first because channel choice is the most immediate operational response to platform participation. Standardized production behaviour is likely to follow because online sales reward consistency, traceability, and product presentation. Green technology adoption may also improve, but usually requires longer adjustment cycles, additional knowledge accumulation, and stronger household capacity.[3]

Based on this logic, the article expects that e-commerce participation will positively affect all three outcomes, but the magnitude of the effect will differ across behavioural domains. In addition, information acquisition capability is expected to reinforce behavioural upgrading, while risk perception may partially restrain it. Heterogeneity in age, planting scale, and household human capital should further shape the comparative strength of these behavioural responses.

From the standpoint of behavioural theory, this article combines the logic of the Theory of Planned Behavior with the insights of information asymmetry and risk-based decision making. E-commerce participation can alter farmers' behavioural attitudes by increasing expected market returns, strengthening awareness of consumer preferences, and making product presentation more visible. It can also reshape perceived behavioural control because access to digital tools, peer examples, and platform guidance may lower the perceived difficulty of trying new marketing or production practices. At the same time, platform-based transactions intensify uncertainty related to returns, complaints, ratings, and logistics, meaning that behavioural upgrading is encouraged and disciplined simultaneously. This duality is why the article does not assume a uniform or frictionless transformation path across all three outcomes.[4]

On this basis, the comparison among the three behavioural domains can be interpreted as a comparison of adjustment costs. Diversified marketing behaviour usually involves the lowest short-run adjustment cost because farmers can add or rearrange channels without fundamentally reconstructing orchard management. Standardized production behaviour

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requires stronger coordination between market demand and production routines, yet it remains closely tied to online reputation, so its response is expected to be relatively strong. Green technology adoption has clear long-run value, but it often requires more specialized knowledge, greater tolerance of uncertainty, and in some cases additional investment. For this reason, the article expects e-commerce participation to exert positive effects on all three outcomes while producing a gradient in effect size, with marketing adjustment likely to be the most immediately responsive domain.

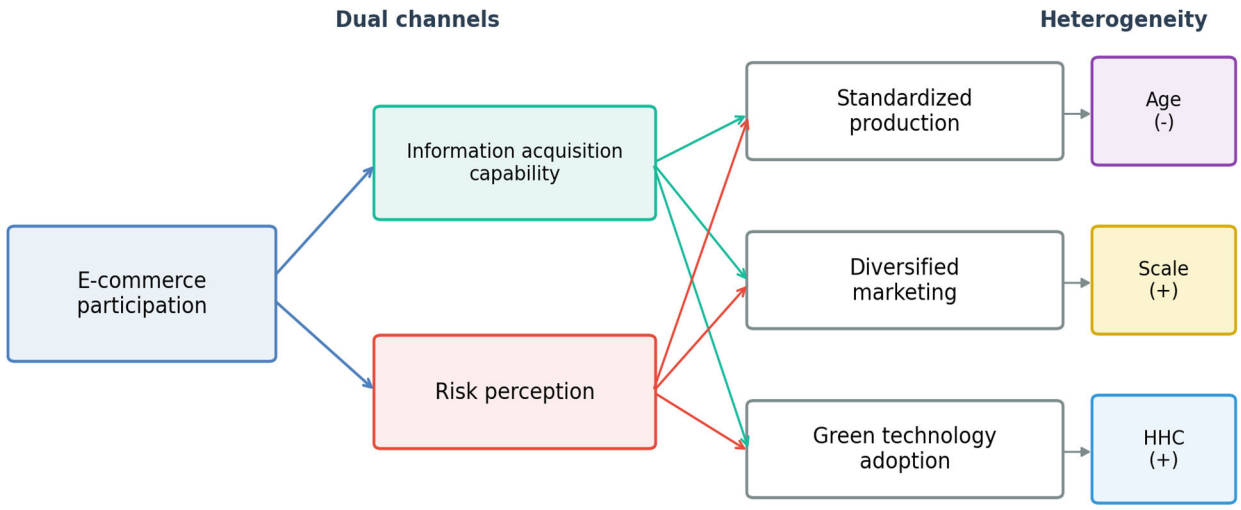

Figure 1. Comparative analytical framework of tripartite behavioural upgrading.

3. Data and Methods

The analysis uses the questionnaire dataset from the dissertation survey of 386 grape growers in Yingkou City, including major production townships in Gaizhou and Dashiqiao. The dataset combines offline field interviews and supplementary online questionnaires. In the dissertation, the core variables were measured through multi-item scales covering e-commerce participation, standardized production behaviour, diversified marketing behaviour, green technology adoption behaviour, information acquisition capability, and risk perception. This article focuses on the comparative direct effects among the three behavioural outcomes while using selected mediation and moderation evidence to interpret the observed differences.

In the empirical analysis, e-commerce participation is treated as the core explanatory variable, while the three behavioural outcomes are estimated separately so that their coefficients can be compared directly. This strategy is analytically useful because it avoids forcing heterogeneous behaviours into a single latent outcome. The interpretation of coefficients is further supported by the dissertation's validated measurement system, where each behavioural construct was built from multiple observed items rather than a single self-reported question. The article then draws on the previously estimated mediation results for information acquisition capability and risk perception, as well as moderation results for age, planting scale, and household human capital, to explain why the three coefficients do not move in parallel. The goal is therefore comparative interpretation rather than re-estimating an entirely new structural model.[5]

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Table 1. Core variables used in the comparative analysis.

Variable	Conceptual focus	Typical measurement content	Role in analysis
E-commerce participation	Digital market engagement	Breadth, depth, and frequency of online participation	Core explanatory variable
Standardized production	Production-side upgrading	Variety choice, grading, packaging, post-harvest consistency	Behavioural outcome 1
Diversified marketing	Channel-side upgrading	Use of platforms, private-domain traffic, live-streaming, offline linkage	Behavioural outcome 2
Green technology adoption	Technology-side upgrading	Water-saving irrigation, green prevention and control, fertilizer optimization	Behavioural outcome 3

4. Results

The regression results show that e-commerce participation has statistically significant positive effects on all three dimensions of growers' behavioural upgrading. However, the strength of the effect differs. Diversified marketing behaviour records the largest coefficient, suggesting that the first response to digital participation is often a reorganization of channels and customer links. Standardized production follows closely, indicating that online reputation and quality feedback also feed back into production-side adjustment. Green technology adoption is significantly promoted as well, but its coefficient is slightly lower, which is consistent with the fact that technology adoption usually requires more time, capital, and learning.

Table 2. Comparative direct effects of e-commerce participation on three behavioural outcomes (N = 386).

Behavioural outcome	Coefficient	Std. Error	t value	Interpretation
Standardized production behaviour	0.428	0.053	8.075	Strong positive effect; quality and consistency become more visible under online transactions
Diversified marketing behaviour	0.465	0.051	9.118	Largest direct effect; channel recombination is the fastest behavioural response
Green technology adoption behaviour	0.412	0.055	7.491	Positive but relatively slower; digital pressure still needs to be converted into technical action

Mechanism evidence from the same dataset helps explain these differences. For standardized production behaviour, the indirect effect through information acquisition capability is 0.215, accounting for 33.4% of the total effect, whereas the indirect effect through risk perception is -0.132, accounting for 20.5% of the total effect. This means that digital participation simultaneously provides knowledge resources and imposes a restraint through uncertainty. In practice, the positive channel tends to encourage growers to improve packaging, grading, and quality consistency, while the negative channel reflects concern about price volatility, returns, and fulfilment risk.

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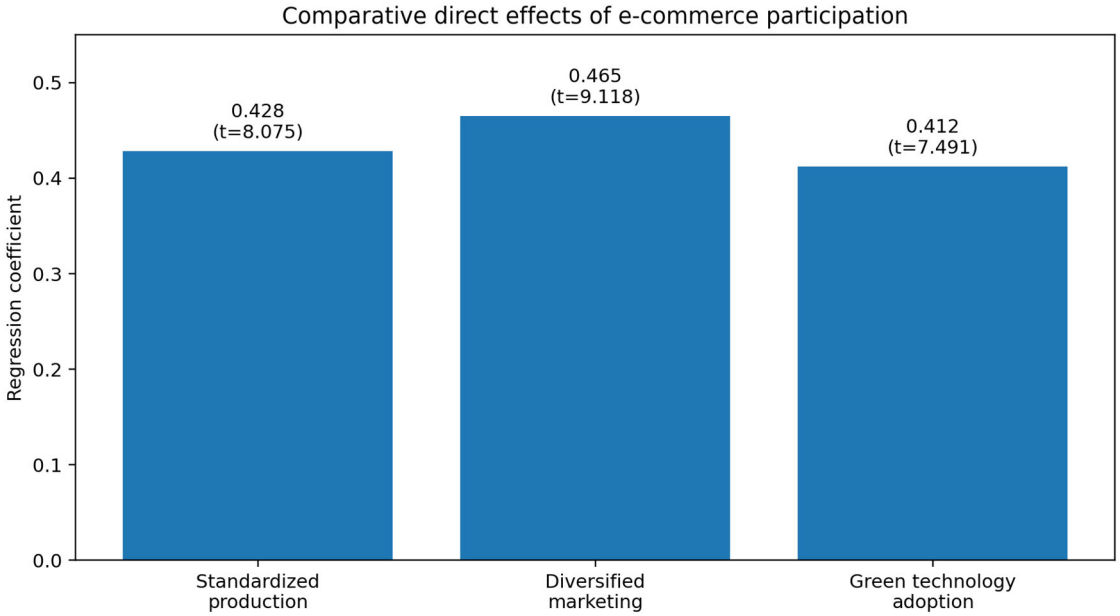

Figure 2. Comparative regression coefficients of e-commerce participation.

Heterogeneity analysis reinforces the comparative interpretation. The moderation coefficient of age is negative across all three outcomes, but the strongest weakening effect appears for diversified marketing behaviour (-0.163). By contrast, planting scale and household human capital have the strongest positive interaction terms for diversified marketing behaviour (0.185 and 0.201 respectively), higher than the corresponding coefficients for standardized production and green technology adoption. This indicates that channel-side adjustment is the most sensitive behavioural domain to household capabilities and resource conditions.

The coefficient ranking also conveys a substantive message about the sequence of digital adaptation. Marketing diversification leads because channel reorganization is the most visible and reversible response to online participation. Farmers can test new customer groups, join platform ecosystems, or combine livestreaming, social commerce, and acquaintance networks with relatively low sunk cost. Production standardization comes next because once online exposure expands, variability in grape quality becomes more costly. Negative reviews, claims, and comparison across sellers create pressure to stabilize orchard management, grading, packaging, and post-harvest handling. Green technology adoption is positively affected as well, but its weaker coefficient indicates that sustainability-oriented changes are less automatic and depend more on accumulated capability, confidence, and household resources.

Table 3. Comparative interpretation of the three behavioural domains.

Outcome	Direct-effect rank	Key mechanism clue	Sensitivity to heterogeneity	Policy priority
Diversified marketing	1st	Immediate response to online traffic and customer connection	Highest	Strengthen training in channel operation, live-streaming, and customer maintenance
Standardized production	2nd	Driven by quality feedback, grading, and platform evaluation	Moderate	Improve packaging standards, traceability, and post-harvest routines
Green technology adoption	3rd	Requires capability accumulation before digital signals become technical action	Moderate to lower	Provide technical extension, demonstration plots, and cost-sharing support

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5. Discussion

The findings suggest that the behavioural consequences of e-commerce participation should be interpreted as a layered process rather than a uniform shift. Channel-side responses occur first because they are closest to the market interface and require lower adjustment costs. Production-side standardization follows as growers attempt to stabilize quality and protect reputation under greater market visibility. Technology adoption improves as well, but it remains more dependent on household resources, learning capacity, and technical support systems. In this sense, e-commerce acts less as a single intervention than as a sequence-triggering mechanism that reorganizes business choices at different speeds.

The results also imply that policy evaluation should avoid over-reliance on a single indicator such as online-sales participation. Two growers may both sell online, yet one may only add a new sales channel while the other may simultaneously improve production standards and adopt greener technologies. The substantive question is therefore not simply whether farmers participate in e-commerce, but whether participation is converted into durable functional upgrading across multiple behavioural domains.

More broadly, the findings contribute to debates on digital rural transformation by showing that e-commerce should be interpreted as a differentiated governance environment rather than a simple sales instrument. Platform participation changes the informational structure of farming, but the behavioural outcome depends on how farmers absorb, interpret, and act on this information under resource constraints. The article therefore supplements income-centred assessments with a function-centred view of upgrading. It suggests that the key policy question is not only how many farmers participate online, but also which operational functions become more responsive after participation and which continue to lag. This distinction is crucial for specialty-fruit regions where product quality, timing, and reputational feedback all matter more than in many bulk-crop contexts.

6. Conclusion and Implications

This article compares the direct behavioural effects of e-commerce participation on standardized production, diversified marketing, and green technology adoption among grape growers in Yingkou City. Three conclusions stand out. First, e-commerce participation significantly promotes all three forms of behavioural upgrading. Second, diversified marketing is the most responsive outcome, indicating that digital participation first reorganizes channel structures and customer relations. Third, the relative strength of each behavioural response is shaped by information capability, risk perception, and household endowments, meaning that digital transformation is conditional rather than automatic.

Accordingly, policy support for specialty-fruit regions should be function-specific. For channel diversification, priority should be given to operational training and digital service support. For production standardization, interventions should emphasize grading, packaging, traceability, and post-harvest quality routines. For green technology adoption, greater attention should be paid to extension services, demonstration effects, and cost-reduction mechanisms so that digital market pressure can be translated into stable technical upgrading.

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