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Examining the Effects of Quality and Psychological Dimensions on Industrial Customers' Acceptance of Emerging Nanotechnology

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A B S T R A C T

Objective: This study examines the effects of Garvin's eight dimensions of quality and two psychological dimensions—perceived risk and trust—on industrial customers' acceptance of nanotechnology in an ethylene nano-adsorbent system used for fruit and vegetable preservation.

Methods and Materials: This applied, cross-sectional survey study employed a 40-item questionnaire using a five-point Likert scale. A total of 213 respondents (71 owners, 71 sales managers, and 71 quality managers) from 100 companies operating in Iran's fruit supply chain were included in the analysis. Following preliminary analyses, including descriptive statistics, one-sample t tests against the scale midpoint of 12, one-way analysis of variance, and Tukey's HSD post hoc test, the structural model was estimated using partial least squares structural equation modeling (PLS-SEM) with 5,000 bootstrap resamples. The robustness of the results was additionally assessed using company-level cluster bootstrapping. Differences across organizational roles were examined through multigroup analysis using the measurement invariance of composites (MICOM) procedure and permutation tests.

Findings: The mean score for all ten dimensions was significantly higher than the scale midpoint (all $p < .001$; Cohen's $d = 0.60–1.86$). The highest perceptions were observed for aesthetics (16.22 out of 20), performance (16.06), and conformance (15.85), whereas the lowest were observed for perceived quality (13.99), durability (14.45), and serviceability (14.46). Significant differences among the three organizational roles were found for nine dimensions ($\eta^2 = 0.085–0.296$); perceived risk was the only dimension that showed no significant difference ($p = .213$). Quality managers scored higher than owners on all dimensions except perceived risk. In the structural model, six paths were significant: trust ($\beta = 0.28$), perceived quality ($\beta = 0.21$), perceived risk ($\beta = 0.19$), performance ($\beta = 0.18$), reliability ($\beta = 0.15$), and conformance ($\beta = 0.12$). The paths for serviceability, aesthetics, features, and durability were nonsignificant; therefore, H1b, H1e, H1g, and H1h were rejected. The model explained 58% of the variance in acceptance ($R^2 = 0.58$; $Q^2 = 0.41$; SRMR = 0.061) and demonstrated satisfactory out-of-sample predictive power. In the multigroup analysis, differences in path coefficients across organizational roles were generally nonsignificant. Only the perceived quality path differed between owners and quality managers at the Bonferroni-adjusted

significance level of .0167. The difference in the perceived risk path between these two groups (p = .030) was significant only at the unadjusted .05 level.
Conclusion: The structural findings indicate that trust, perceived quality, and perceived risk are the most important predictors of acceptance. Accordingly, vendors should simultaneously emphasize transparency and trust building, improve perceived quality, and reduce safety-related concerns.
Keywords: *nanotechnology, technology acceptance, quality dimensions, perceived risk, trust, industrial customers, structural equation modeling*

1 Introduction

Technological innovation has become a central source of competitive advantage in industrial markets, yet the commercial success of an emerging technology depends not only on its technical superiority but also on whether organizational buyers perceive sufficient value, acceptable risk, and credible evidence to adopt it. This issue is particularly salient in business-to-business (B2B) markets, where purchasing decisions are generally more complex than consumer purchases because they involve multiple organizational actors, economic and operational consequences, longer-term relationships, and greater accountability for decision outcomes. Contemporary B2B research increasingly emphasizes that organizational purchasing behavior emerges from the interaction of functional value, relationship quality, customer engagement, perceived uncertainty, and organizational context rather than from a single product attribute (Bilro et al., 2023; Nyadzayo et al., 2020; Sheeri & Sujaya, 2023). Accordingly, understanding the acceptance of emerging industrial technologies requires an integrative perspective that simultaneously addresses the objective and perceived quality of the offering and the psychological mechanisms through which buyers evaluate uncertainty and supplier credibility.

The challenge is particularly important for technologies whose benefits are not immediately observable before purchase or whose technical mechanisms may be unfamiliar to organizational customers. In such circumstances, adoption becomes partly an evaluative judgment about anticipated performance and partly a decision under uncertainty. Research on industrial innovation adoption indicates that organizational buyers assess technological innovations in terms of their expected usefulness, compatibility with operational requirements, performance advantages, and perceived consequences of adoption (Thanabodypath et al., 2021). The successful commercialization of technologically advanced B2B offerings therefore requires more than the existence of a technically functional product. Firms must translate technological capabilities into dimensions of value that industrial customers can recognize, evaluate, and trust. Evidence from the commercialization of technology-intensive business models similarly suggests that the launch and acceptance of emerging technologies are contingent on the alignment of technological value propositions with customer needs and the ability of suppliers to communicate and deliver those benefits effectively (Falkenreck et al., 2023). Research involving nanotechnology-oriented business models further demonstrates that technological novelty must ultimately be transformed into viable customer value and commercially sustainable market offerings (Akbar & Prasetio, 2023).

Nanotechnology represents an important domain in which this distinction between technological capability and market acceptance is especially relevant. Nanotechnology-based solutions can alter material properties, improve functional performance, enhance resource efficiency, and contribute to new methods of production, packaging, storage, and preservation. Nevertheless, industrial customers may have limited direct knowledge of nanoscale mechanisms and may consequently evaluate nanotechnology-based products through more accessible indicators such as product performance, reliability, durability, safety, supplier reputation, and perceived quality. The adoption decision therefore involves both technological and managerial considerations. Within Industry 4.0 environments, the strategic alignment of industrial operations, marketing, and sustainability has become increasingly important because customers expect innovations to provide not only technical efficiencies but also broader economic and operational value (Pandya et al., 2023). Likewise, research on responsible business practices suggests that industrial value increasingly incorporates environmental, social, and ethical considerations alongside conventional economic outcomes (Anand et al., 2023; Jha, 2021). These developments make the assessment of customer perceptions particularly important when emerging technologies are introduced into supply chains associated with food quality, preservation, waste reduction, and product safety.

The fruit and vegetable supply chain provides a relevant context for investigating these issues because product

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deterioration has direct economic consequences for producers, distributors, retailers, and other supply-chain participants. Technologies capable of slowing deterioration and extending effective storage periods may therefore create substantial B2B value. An ethylene nano-adsorbent system is one such technological solution because it is designed to manage ethylene-related processes associated with fruit and vegetable ripening and deterioration. From an industrial purchasing perspective, however, the technological principle itself does not guarantee adoption. Organizational buyers must believe that the system performs effectively, functions reliably under actual operating conditions, conforms to expected requirements, provides adequate durability and serviceability, and offers sufficient advantages over existing alternatives. Studies of B2B service and product evaluations consistently show that perceived service quality and delivered value influence satisfaction, loyalty, and continued commercial relationships (Dung & Tu, 2023; Zou et al., 2021). Similarly, the development of service-quality models in organizational and institutional purchasing settings demonstrates that buyers form multidimensional judgments rather than relying on a single indicator of quality (Nandankar et al., 2023). Consequently, a multidimensional quality framework is particularly appropriate for evaluating industrial customers' responses to a technologically novel product.

Garvin's eight dimensions of quality—performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality—provide a useful conceptual framework for such an assessment. Although these dimensions are conceptually distinct, together they capture multiple ways in which organizational buyers may determine whether an offering meets operational and commercial expectations. Performance reflects the primary functional capability of the product, whereas features represent supplementary characteristics that may increase its usefulness. Reliability concerns consistency of operation, and conformance reflects the degree to which the product meets expected specifications or requirements. Durability captures the expected useful life or persistence of performance, while serviceability concerns the ease and adequacy of support, maintenance, or problem resolution. Aesthetics represents the sensory and presentational characteristics of the offering, and perceived quality reflects the buyer's more general judgment of product superiority when complete technical information is unavailable. Such multidimensional evaluation is consistent with B2B research showing that customer value arises from combinations of functional, relational, experiential, and reputational signals rather than from price or technical performance alone (Cheng et al., 2022; Saragih, 2024).

Quality perceptions also acquire particular significance in long-term buyer–supplier relationships. Industrial purchasing commonly entails repeated exchanges, interorganizational dependence, and relationship-specific expectations. Relationship-management research demonstrates that relationship quality contributes substantially to B2B outcomes because buyers evaluate suppliers not only according to transactional results but also according to the consistency and dependability of ongoing interactions (Lasrado et al., 2022). Relational benefits can strengthen commitment and loyalty even when the exchange is not governed by highly formal contractual mechanisms (Lee et al., 2022). Likewise, perceptions of service performance can shape the quality and continuity of B2B relationships when suppliers demonstrate competence, responsiveness, collaboration, and an ability to support customers over time (Zou et al., 2021). Recent work on servitization additionally indicates that service-based value creation does not automatically generate favorable repurchase intentions; customers' perceptions of fairness and the manner in which aftermarket value is delivered remain important (Lin, 2026). These findings suggest that serviceability and other quality dimensions should be examined as potentially distinct determinants of industrial technology acceptance rather than assuming that technical performance alone determines adoption.

At the same time, quality judgments are embedded within broader perceptions of the supplier and the commercial relationship. Industrial buyers frequently rely on reputation, brand signals, interpersonal interaction, and accumulated experience to interpret information about products whose quality cannot be completely verified prior to adoption. A favorable B2B brand can communicate both competence and relational warmth, thereby helping customers form expectations about the supplier's capability and intentions (Aagerup et al., 2022). Brand equity similarly provides signals that facilitate organizational customers' assessment of suppliers and their offerings (Fagundes et al., 2022; Tjandra et al., 2020). In contemporary B2B environments, these signals are increasingly communicated through digital platforms, social media, and technology-mediated interactions. Research shows that social media has become an important component of B2B marketing activities, influencing communication, customer interaction, information exchange, and relationship development

(Dwivedi et al., 2021; Zhang & Du, 2020). Salespeople's use of social media can also strengthen social capital and facilitate value co-creation as well as cross- and up-selling opportunities (Itani et al., 2022). These communication mechanisms are especially relevant for novel technologies because organizational customers may require accessible, credible, and repeated information before developing confidence in an unfamiliar solution.

Trust is therefore a central psychological dimension in the adoption of emerging B2B technologies. Trust reduces the perceived vulnerability inherent in relying on another organization and becomes particularly influential when customers cannot fully evaluate the technical characteristics or future performance of an offering at the time of purchase. Empirical research in B2B settings demonstrates that trust in suppliers contributes to perceived value and loyalty (Rineggo et al., 2023). Trust is also multidimensional and may contain affect-based elements that complement rational assessments of competence and reliability in buyer–supplier relationships (Rungsithong & Meyer, 2024). Research on long-term B2B relationships likewise identifies trust as a foundational mechanism through which repeated interactions are transformed into commitment and relationship continuity (Sheeri & Sujaya, 2023). In technology-intensive markets, supplier trust may therefore serve as an interpretive bridge between technical claims and customers' willingness to adopt. Even technologically sophisticated digital interactions illustrate this mechanism: business customers' willingness to use technologies such as chatbots depends partly on how they interpret the utility, credibility, and relational consequences of technology-mediated service encounters (Maga & Bodlaj, 2024).

Closely related to trust is perceived risk. Industrial technology adoption often exposes buyers to financial, operational, performance, reputational, and safety-related consequences, making risk assessment a core component of organizational purchasing. Perceived risk is not necessarily identical to objectively measurable technological risk; rather, it reflects the buyer's subjective assessment of uncertainty and the potential negative consequences of a decision. Research shows that product quality can influence repurchase intentions partly through perceived risk, indicating that quality signals and risk perceptions are closely interconnected in purchasing decisions (Wisnujati et al., 2024). In B2B markets, reliance on suppliers and favorable brand image can reduce risk perceptions and thereby support stronger purchasing relationships (Kittur & Chatterjee, 2023). This relationship is especially consequential for nanotechnology-based products because buyers may perceive uncertainty regarding performance consistency, safety, compatibility, or downstream reactions even when the underlying technology has demonstrated functional benefits. Hence, lower perceived risk may directly facilitate technology acceptance, while trust may reduce uncertainty by increasing confidence in information provided by suppliers.

The ethical and relational conduct of suppliers may further shape this risk–trust mechanism. B2B exchanges are increasingly evaluated in terms of transparency, fairness, responsible conduct, and the perceived legitimacy of supplier behavior (Anand et al., 2023). Ethical perceptions can influence buyer–supplier relationships, particularly under conditions of disruption and uncertainty (Bag et al., 2023). Similarly, organizational customers' responses to service failures depend not only on the outcome received but also on locus attribution and perceptions of justice during service recovery (Oflaç et al., 2021). For novel technologies, transparent communication regarding product composition, application, limitations, and safety may therefore serve both an informational and relational function. Such transparency can reduce uncertainty while signaling that the supplier is willing to accept accountability for its claims. This issue is particularly relevant where product-related risks interact with broader sustainability concerns. Evidence from research on climate-related risks and branding indicates that stakeholder assessments of sustainability claims can affect how firms and offerings are interpreted in the marketplace (Mahmoud et al., 2023), while environmental marketing practices in B2B contexts can foster satisfaction and loyalty when environmental value is credibly delivered (Gelderman et al., 2021).

Organizational acceptance, however, cannot be treated as if the organization were a single individual with a homogeneous perception. B2B purchase decisions frequently involve multiple actors occupying different functional and hierarchical positions, each of whom may evaluate the same technology according to different criteria. Owners may be particularly attentive to investment consequences, strategic value, and overall business risk; sales managers may focus more strongly on customer response, marketability, and commercial implications; and quality managers may emphasize technical performance, reliability, conformance, and product-related standards. Research on B2B purchase engagement underscores that organizational customer behavior is multidimensional and influenced by different drivers throughout the purchasing

relationship (Nyadzayo et al., 2020). Sales research also indicates that perceptions of customer relationships and customer ownership may vary according to organizational responsibilities and the role of particular employees in managing accounts (Fergurson et al., 2024). These differences imply that aggregate organizational scores may obscure meaningful intraorganizational heterogeneity in technology evaluation.

The possibility of role-based differences becomes even more relevant when innovation requires specialized knowledge. Quality managers may possess more technical information about product performance and therefore evaluate a nano-enabled system differently from owners or commercial managers. Conversely, owners may assign greater weight to perceived risk and overall quality when they are ultimately responsible for investment outcomes. This reinforces the importance of examining not merely whether industrial customers accept a technology, but also whether the determinants of acceptance differ across organizational roles. B2B research increasingly favors such relational and actor-sensitive approaches because value creation occurs through interactions among individuals, organizational resources, and relationship structures (Saragih, 2024). The importance of interpersonal information exchange is also reflected in systematic research on B2B word-of-mouth, which shows that organizational purchase decisions can be influenced by information transmitted through professional and interorganizational networks (Ishii & Kikumori, 2023). In digital B2B environments, word-of-mouth and customer value can jointly affect sales performance, further demonstrating that market acceptance depends on both product-related judgments and information processes (Mai & Liao, 2021).

Advances in digitalization have intensified these dynamics. Artificial intelligence, digital platforms, automated communication systems, and data-driven marketing practices increasingly shape how suppliers communicate complex technological value to business customers (Keegan et al., 2022). Social media and digital channels enable firms to explain technical offerings, demonstrate applications, answer questions, and develop relationships before and after purchase (Dwivedi et al., 2021). Yet increased information availability does not necessarily eliminate uncertainty; rather, buyers must assess the credibility and relevance of the information they receive. For emerging nanotechnology, this makes evidence-based communication particularly important. Suppliers may need to translate technical performance into customer-relevant outcomes, demonstrate consistency and safety, and respond to concerns in ways that strengthen both perceived quality and trust. B2B sales research shows that value creation develops throughout the sales process and depends on how sellers communicate, interact, and adapt their activities to customer requirements (Cheng et al., 2022). Similarly, the strategic use of relational resources can strengthen co-creation and increase customers' involvement in defining and realizing value (Saragih, 2024).

The application of these principles to fruit-supply-chain technologies is also consistent with broader developments in B2B marketing across specialized sectors. Research in healthcare and other professionally intensive markets shows that B2B marketing strategies increasingly combine technical expertise with relationship management, communication, and value demonstration (Ferreira et al., 2021). In these contexts, suppliers must often convince professional buyers whose judgments are based on a combination of objective performance indicators and subjective confidence in the provider. This is comparable to the adoption environment for a novel postharvest nanotechnology, where industrial customers may simultaneously consider measurable functional benefits and less tangible perceptions of credibility, safety, and product quality. Consequently, evaluating only technological performance would provide an incomplete explanation of acceptance.

Despite the expanding literature on B2B customer behavior, relationship quality, digital marketing, trust, risk, service quality, and industrial innovation adoption, these streams of research are frequently examined separately. Existing studies have advanced understanding of customer engagement (Nyadzayo et al., 2020), relationship quality (Lasrado et al., 2022), supplier trust (Rineggo et al., 2023; Rungsithong & Meyer, 2024), risk reduction (Kittur & Chatterjee, 2023), service quality (Dung & Tu, 2023; Nandankar et al., 2023), digital B2B interaction (Keegan et al., 2022; Maga & Bodlaj, 2024), and innovation adoption (Thanabodypath et al., 2021), but comparatively less attention has been directed toward models that integrate a comprehensive set of product-quality dimensions with perceived risk and trust in explaining acceptance of a specific emerging nanotechnology by industrial customers. Furthermore, prior work demonstrates that relational, ethical, environmental, brand-related, and informational factors can shape B2B evaluations (Aagerup et al., 2022; Bag et al., 2023; Fagundes et al., 2022; Gelderman et al.,

2021), suggesting that the psychological interpretation of technical quality deserves greater attention.

A further gap concerns heterogeneity among organizational decision makers. Studies of B2B behavior increasingly recognize that buying organizations contain multiple actors, yet empirical analyses often aggregate their responses and thereby assume uniform perceptions. Such aggregation can conceal differences in how decision makers interpret performance, durability, serviceability, perceived quality, trust, and risk. This limitation is consequential from both theoretical and managerial perspectives. Theoretically, different roles may assign different weights to the predictors of technology acceptance. Managerially, suppliers seeking to commercialize a nano-enabled industrial product may need to communicate differently with owners, sales managers, and quality managers. A quality manager may respond more strongly to reliability and conformance evidence, while an owner may require stronger reassurance regarding perceived quality and risk, and commercially oriented managers may focus on customer-facing value. Understanding these differences can improve segmentation within organizational accounts and contribute to more effective technology commercialization, relationship development, and sales communication.

Accordingly, the aim of this study is to examine the effects of Garvin's eight quality dimensions—performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality—together with perceived risk and trust on industrial customers' acceptance of an ethylene nano-adsorbent system for fruit and vegetable preservation, while also assessing whether these perceptions and structural relationships differ among company owners, sales managers, and quality managers.

2 Methods and Materials

The present study is applied in terms of purpose and descriptive in terms of data collection, employing a cross-sectional survey design and a quantitative approach. Structural equation modeling was used as the primary analytical method to estimate the measurement model, representing the relationships between items and constructs, and the structural model, representing the relationships among constructs, simultaneously. The data were also analyzed using one-sample *t* tests to compare the mean of each dimension with the scale midpoint and one-way analysis of variance accompanied by post hoc tests. Partial least squares structural equation modeling (PLS-SEM) was selected as the estimation method because (a) the model is complex, comprising 11 constructs and approximately 40 items, and covariance-based estimation with a sample of approximately 213 observations would result in a highly unfavorable parameter-to-sample-size ratio; (b) the study aims to explain and predict acceptance and has an exploratory orientation; (c) data obtained using a five-point Likert scale do not exhibit multivariate normality, whereas PLS-SEM does not require the assumption of multivariate normality; and (d) organizational roles can be examined through multigroup analysis within this approach (Hair, Risher, Sarstedt, & Ringle, 2019; Hair, Hult, Ringle, & Sarstedt, 2022; Cheah, Amaro, & Roldán, 2023).

Iran is one of the major producers of fruits and vegetables; however, the absence or inadequacy of postharvest technologies results in the spoilage of a substantial proportion of agricultural products. Estimates vary from 5% to 50%, depending on the product, season, and geographical region (Panahizadeh et al., 2022). Reducing these losses can increase the profitability of the horticultural sector. Because ethylene gas is one of the most important factors contributing to fruit ripening and deterioration, an "ethylene nano-adsorbent" technology can potentially have a substantial effect on reducing postharvest losses (Maria et al., 2022). The fundamental question, however, is whether industrial customers will accept this technology. Accordingly, the nanotechnology-based product evaluated in this study is an "ethylene nano-adsorbent system." The principal nanomaterial used in the system is zeolite, which is a natural mineral material. The statistical population consisted of companies operating within the fruit supply chain.

The selected sample consisted of 100 companies. To enable comparisons of perceptions, three individuals from each company—an owner, a sales manager, and a quality manager—were asked to complete the 40-item questionnaire. Following data screening, 213 questionnaires comprising 71 owners, 71 sales managers, and 71 quality managers were included in the analysis. Sample-size adequacy was assessed in two ways. First, according to the 10-times rule, the maximum number of incoming paths to a construct is 10; thus, at least 100 observations are required. However, this rule represents only a rough guideline and should preferably be supplemented by statistical power analysis (Hair et al., 2019). Second, a statistical power analysis was conducted using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009), assuming a medium effect size (f^2 = 0.15), a significance level of .05, statistical power of .80,

and 10 predictors, which indicated a minimum requirement of approximately 118 observations. The sample of 213 exceeded both criteria. Nevertheless, for multigroup analysis, each group contained only 71 observations, which is below the threshold implied by the 10-times rule; consequently, comparisons of path coefficients across groups should be regarded as exploratory. Furthermore, because three respondents were drawn from each company, the observations were not fully independent and had a clustered data structure.

The data collection instrument was a 40-item questionnaire using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The questionnaire was developed on the basis of Garvin's quality dimensions (Garvin, 1987) and the psychological dimensions examined in this study. Each dimension was measured using four items, resulting in a raw score ranging from 4 to 20, with a scale midpoint of 12. The acceptance construct (ACC) was defined using behavioral items concerning continued purchasing (Item 11), purchasing other nanotechnology-based products (Item 38), and recommending the purchase to others (Item 40), whereas trust was measured using Items 37 and 39. Table 1 presents the structure of the model.

Table 1

Structure of the Measurement and Structural Models

Role in the Model	Symbol	Construct	Items	Number of Items
Exogenous	PERF	Performance	1–4	4
Exogenous	SERV	Serviceability	5–8	4
Exogenous	RELI	Reliability	9, 10, and 12	3
Exogenous	PQ	Perceived Quality	13–16	4
Exogenous	AEST	Aesthetics	17–20	4
Exogenous	CONF	Conformance	21–24	4
Exogenous	FEAT	Features	25–28	4
Exogenous	DUR	Durability	29–32	4
Exogenous	PR	Perceived Risk (reverse-coded)	33–36	4
Exogenous	TRU	Trust	37 and 39	2
Endogenous	ACC	Nanotechnology Acceptance	11, 38, and 40	3

In Table 1, the "Role in the Model" column indicates that the 10 quality-related and psychological constructs are exogenous predictors, whereas acceptance (ACC) is an endogenous dependent construct. The "Items" column identifies the questionnaire items associated with each construct, and the "Number of Items" column indicates the number of corresponding items. The questionnaire contains a total of 40 items, comprising seven four-item constructs, two three-item constructs—reliability and acceptance—and one two-item construct, namely trust. Perceived risk was measured using reverse-coded items; consequently, a higher score indicates lower perceived risk, and a positive path coefficient from perceived risk to acceptance therefore represents the positive effect of "risk reduction." Constructs measured with relatively few items, particularly trust with only two items, have inherent limitations in terms of reliability and validity, which are addressed in the limitations section.

The reliability and validity of the instrument were examined within the PLS-SEM measurement-model assessment framework (Hair et al., 2019). Indicator reliability was assessed through factor loadings, with a minimum recommended loading of .70; loadings between .60 and .70 were considered acceptable only when composite reliability and average variance extracted were satisfactory. Construct reliability was evaluated using Cronbach's alpha, ρA, and composite reliability (CR), with acceptable values ranging from .70 to .95. Convergent validity was assessed using the average variance extracted (AVE ≥ .50). Factor loadings, Cronbach's alpha, ρA, CR, and AVE for all constructs are reported in Table 6.

- **Data preparation:** Missing data, outliers, skewness, and kurtosis were examined. Common method bias was assessed using Harman's single-factor test and full collinearity VIF, with values below 3.3 considered acceptable (Kock, 2015). This assessment was particularly important because all three groups completed the same questionnaire and the data were self-reported (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Podsakoff, Podsakoff, Williams, Huang, & Yang, 2024).

- **Preliminary analyses:** Descriptive statistics, one-sample *t* tests against the value of 12 accompanied by Cohen's *d* effect size, and one-way analysis of variance with Tukey's HSD post hoc test and η^2 were used to compare the three organizational roles. Effect sizes were interpreted according to Cohen's criteria (Cohen, 1988).
- **Measurement-model assessment:** Factor loadings, CR, and AVE were evaluated.
- **Structural-model assessment:** Collinearity among predictors was evaluated using VIF values, with values below 3 considered desirable and values below 5 considered acceptable. Path coefficients (β) were estimated using 5,000 bootstrap resamples and 95% bias-corrected and accelerated (BCa) confidence intervals. The coefficient of determination (R^2), effect size (f^2), predictive relevance index (Q^2), and PLSpredict procedure were used to evaluate out-of-sample predictive power (Shmueli, Sarstedt, Hair, Cheah, Ting, Vaithilingam, & Ringle, 2019). Overall model fit was descriptively reported using the standardized root mean square residual (SRMR), with values below .08 considered acceptable (Hu & Bentler, 1999; Henseler et al., 2014).
- **Effect of the clustered data structure:** Because three respondents were sampled from each company, bootstrapping at the company level—resampling companies rather than individual respondents—was also conducted and compared with conventional bootstrapping to avoid underestimating standard errors (Huang, 2018).
- **Testing Hypothesis 2 through multigroup analysis:** Measurement invariance of composite constructs was first evaluated using the MICOM procedure (Henseler, Ringle, & Sarstedt, 2016). Differences in path coefficients between each pair of the three groups were subsequently examined using permutation tests, with a Bonferroni adjustment for the three comparisons, resulting in a significance level of .0167 (Cheah et al., 2023). Given the sample size of 71 observations in each group, these tests have limited statistical power and their results should therefore be considered exploratory.
- **Software:** SPSS was used for preliminary analyses, and SmartPLS 4 was used for PLS-SEM.

3 Findings and Results

The analyzed data consisted of 213 respondents, including 71 owners, 71 sales managers, and 71 quality managers from companies operating in the fruit supply chain. Approximately 97% of respondents were men and 3% were women, reflecting the predominantly male composition of this supply chain in Iran.

Table 2 presents the descriptive statistics for the 10 dimensions. The score for each dimension represents the sum of four five-point items and ranges from 4 to 20. Aesthetics had the highest perceived level (M = 16.22; 81.1% of the maximum score), followed by performance (M = 16.06) and conformance (M = 15.85). The lowest perceived levels were observed for perceived quality (M = 13.99), durability (M = 14.45), and serviceability (M = 14.46). The two psychological dimensions, perceived risk (M = 15.13; 75.6%) and trust (M = 15.25; 76.3%), were at relatively favorable but moderate levels.

Table 2

Descriptive Statistics (N = 213)

Dimension	Symbol	Mean	SD	Variance	SE	Minimum	Maximum	Percentage of Maximum
Performance	PERF	16.06	3.02	9.15	0.207	6	20	80.3%
Serviceability	SERV	14.46	3.52	12.41	0.241	5	20	72.3%
Reliability	RELI	14.52	3.28	10.75	0.225	5	20	72.6%
Perceived Quality	PQ	13.99	3.30	10.91	0.226	5	20	70.0%
Aesthetics	AEST	16.22	2.51	6.29	0.172	8	20	81.1%
Conformance	CONF	15.85	2.07	4.28	0.142	12	20	79.2%
Features	FEAT	15.12	2.27	5.17	0.156	9	20	75.6%
Durability	DUR	14.45	2.75	7.57	0.189	6	20	72.2%
Perceived Risk	PR	15.13	2.91	8.47	0.199	7	20	75.6%
Trust	TRU	15.25	2.81	7.91	0.193	8	20	76.3%

In Table 2, the columns report, respectively, the mean, standard deviation, variance, standard error of the mean (standard deviation divided by the square root of 213), minimum and maximum observed scores, and the mean expressed as a percentage of the maximum possible score of 20. The means range from 13.99 to 16.22, corresponding to 70.0%–81.1% of the maximum score, indicating generally positive but not extreme perceptions. The "Percentage of Maximum" is identical for perceived risk and features (75.6%). Because perceived-risk items were reverse-coded, a score of 15.13 indicates relatively low perceived risk. The greatest dispersion in respondents' views was observed for serviceability (variance = 12.41; SD = 3.52), perceived quality (variance = 10.91), and reliability (variance = 10.75), indicating greater heterogeneity of perceptions on these dimensions. The lowest dispersion was observed for conformance (variance = 4.28) and features (variance = 5.17), indicating relatively similar perceptions among customers regarding these two dimensions. For conformance, no respondent scored below the scale midpoint of 12. The maximum observed score was 20 for every dimension, suggesting the possibility of ceiling effects and negative skewness, which should be considered when interpreting the results.

To determine whether the mean score for each dimension was higher than the scale midpoint of 12, one-sample t tests were conducted (Table 3). The mean scores for all 10 dimensions were significantly higher than 12 (all $p < .001$), with Cohen's d ranging from 0.60 for perceived quality to 1.86 for conformance. These findings indicate that industrial customers hold positive perceptions across all dimensions.

Table 3

One-Sample t Tests (Test Value = 12)

Dimension	*t*	*df*	*p*	Mean Difference	95% CI	Cohen's *d*
Performance	19.573	212	< .001	4.056	3.648–4.465	1.34
Serviceability	10.211	212	< .001	2.465	1.989–2.941	0.70
Reliability	11.201	212	< .001	2.516	2.074–2.959	0.77
Perceived Quality	8.797	212	< .001	1.991	1.545–2.437	0.60
Aesthetics	24.569	212	< .001	4.221	3.882–4.559	1.68
Conformance	27.117	212	< .001	3.845	3.566–4.125	1.86
Features	20.009	212	< .001	3.117	2.810–3.425	1.37
Durability	12.976	212	< .001	2.446	2.074–2.818	0.89
Perceived Risk	15.680	212	< .001	3.127	2.734–3.520	1.07
Trust	16.886	212	< .001	3.254	2.874–3.633	1.16

In Table 3, df = 212 (N − 1). The "Mean Difference" represents the difference between the mean of each dimension and the reference value of 12; for example, 16.06 − 12 ≈ 4.06 for performance. The 95% confidence interval for this difference does not include zero for any dimension. Cohen's d was calculated by dividing the mean difference by the standard deviation and was interpreted according to Cohen's (1988) criteria of approximately 0.2 for a small effect, 0.5 for a medium effect, and 0.8 for a large effect. Accordingly, perceived quality (0.60), serviceability (0.70), and reliability (0.77) showed medium to nearly large effects, whereas the other seven dimensions showed large effects: durability (0.89), perceived risk (1.07), trust (1.16), performance (1.34), features (1.37), aesthetics (1.68), and conformance (1.86). The largest t statistics were observed for conformance (27.12) and aesthetics (24.57), whereas the smallest was observed for perceived quality (8.80). The results remained significant even after applying a Bonferroni correction for 10 tests (.05/10 = .005). It should be emphasized that the scale midpoint represents a conventional reference point and that statistical significance does not necessarily imply "high quality" in an absolute sense.

The results of the one-way ANOVAs showed significant differences among owners, sales managers, and quality managers on nine of the 10 dimensions. Perceived risk was the only dimension for which the difference was nonsignificant, $F(2, 210) = 1.56$, $p = .213$. Effect sizes (η^2) ranged from .085 for aesthetics to .296 for perceived quality. After perceived quality, durability (.209) and performance (.176) showed the largest proportions of variance attributable to organizational role (Table 4).

Table 4

One-Way Analysis of Variance (Between-Groups df = 2; Within-Groups df = 210)

Dimension	Between-Groups SS	Within-Groups SS	Within-Groups MS	*F*	*p*	η^2
Performance	341.606	1597.718	7.608	22.450	< .001	0.176
Serviceability	268.423	2362.563	11.250	11.930	< .001	0.102
Reliability	344.347	1934.845	9.214	18.687	< .001	0.151
Perceived Quality	683.559	1628.423	7.754	44.076	< .001	0.296
Aesthetics	112.939	1219.690	5.808	9.723	< .001	0.085
Conformance	135.239	772.648	3.679	18.379	< .001	0.149
Features	119.474	976.592	4.650	12.845	< .001	0.109
Durability	335.615	1269.014	6.043	27.769	< .001	0.209
Perceived Risk	26.225	1769.352	8.425	1.556	.213	0.015
Trust	108.282	1568.028	7.467	7.251	.001	0.065

In Table 4, each row represents a separate analysis of variance. The between-groups sum of squares reflects differences among the means of the three organizational roles, whereas the within-groups sum of squares represents variability within each role. The F statistic is the ratio of the between-groups mean square to the within-groups mean square. η^2, calculated as the between-groups sum of squares divided by the total sum of squares, indicates the proportion of variance explained by organizational role. According to the conventional criteria of .01 for a small effect, .06 for a medium effect, and .14 for a large effect (Cohen, 1988), organizational role had a large effect on perceived quality (.296), durability (.209), performance (.176), reliability (.151), and conformance (.149); a medium effect on features (.109), serviceability (.102), aesthetics (.085), and trust (.065); and a negligible effect on perceived risk (.015).

Tukey's HSD post hoc test (Table 5) indicated that quality managers reported higher mean scores than owners on every dimension except perceived risk. Quality managers also reported higher scores than sales managers for performance, reliability, perceived quality, conformance, and trust. In contrast, differences between owners and sales managers were nonsignificant for reliability, perceived quality, conformance, and trust.

Table 5

Tukey's HSD Multiple Comparisons (Mean Difference I − J; Standard Error Is Identical for All Comparisons Within Each Dimension)

Dimension	Owner − Sales	*p*	Owner − Quality	*p*	Sales − Quality	*p*	SE
Performance	-1.423	.007	-3.099	< .001	-1.676	.001	0.463
Serviceability	-1.718	.007	-2.718	< .001	-1.000	.180	0.563
Reliability	-1.169	.059	-3.085	< .001	-1.915	.001	0.509
Perceived Quality	-0.944	.110	-4.183	< .001	-3.239	< .001	0.467
Aesthetics	-1.042	.029	-1.775	< .001	-0.732	.169	0.404
Conformance	-0.028	.996	-1.704	< .001	-1.676	< .001	0.322
Features	-1.014	.015	-1.831	< .001	-0.817	.064	0.362
Durability	-2.169	< .001	-2.972	< .001	-0.803	.129	0.413
Perceived Risk	-0.606	.429	-0.831	.205	-0.225	.889	0.487
Trust	-0.366	.704	-1.662	.001	-1.296	.014	0.459

In Table 5, a negative mean difference (I − J) indicates that the first group reported a lower score than the second group. For example, −3.099 for performance indicates that owners scored approximately three points lower than quality managers on the 4–20 scale. The standard error is identical across comparisons within each row because the group sizes were equal (n = 71). The overall pattern is as follows: owner–quality manager comparisons were significant for nine of the 10 dimensions, including eight dimensions with $p < .001$, with the largest gaps observed for perceived quality (−4.183), performance (−3.099), reliability (−3.085), durability (−2.972), and serviceability (−2.718). Owner–sales manager comparisons were significant for five dimensions—performance, serviceability, aesthetics, features, and durability—whereas sales manager–quality manager comparisons were significant for five

dimensions—performance, reliability, perceived quality, conformance, and trust. Accordingly, three distinct patterns can be identified: (1) for serviceability, aesthetics, features, and durability, owners scored lower than the other two groups, whereas sales managers and quality managers did not differ significantly; (2) for reliability, perceived quality, conformance, and trust, owners and sales managers were similar, whereas quality managers reported higher scores; and (3) for performance, all three groups differed from one another in the order owner < sales manager < quality manager. No pairwise comparison was significant for perceived risk. Tukey's HSD controls the familywise error rate within each dimension rather than across all 10 ANOVAs.

The decision rule for each subhypothesis was as follows: a hypothesis was supported when the path coefficient (β) was positive and its 95% BCa confidence interval did not include zero.

Table 6

Factor Loadings, Reliability, and Convergent Validity

Construct	Factor Loading Range	Cronbach's α	ρA	CR	AVE	Assessment
PERF	0.76–0.84	0.83	0.86	0.88	0.64	Satisfactory
SERV	0.70–0.79	0.78	0.81	0.83	0.55	Satisfactory
RELI	0.73–0.80	0.77	0.80	0.81	0.59	Satisfactory
PQ	0.66–0.75	0.76	0.79	0.81	0.51	Acceptable (loading of 0.60–0.70 with adequate CR and AVE)
AEST	0.72–0.79	0.80	0.83	0.84	0.57	Satisfactory
CONF	0.78–0.85	0.84	0.87	0.89	0.66	Satisfactory
FEAT	0.70–0.77	0.78	0.81	0.83	0.54	Satisfactory
DUR	0.72–0.78	0.79	0.82	0.84	0.56	Satisfactory
PR	0.79–0.86	0.85	0.89	0.90	0.69	Satisfactory
TRU	0.86–0.88	0.82	0.85	0.86	0.76	Satisfactory
ACC	0.80–0.84	0.82	0.85	0.86	0.67	Satisfactory

In Table 6, all criteria satisfy the commonly accepted PLS-SEM thresholds (Hair et al., 2019). Factor loadings range from .66 to .88. For all constructs except perceived quality, the minimum loading is at least .70. The loading of .66 for perceived quality is acceptable given the construct's CR of .81 and AVE of .51. Cronbach's alpha values range from .76 to .85, ρA values range from .79 to .89, and composite reliability values range from .81 to .90. Thus, all values exceed .70 and remain below .95, indicating no evidence of indicator redundancy, while ρA falls between Cronbach's alpha and CR for each construct. AVE ranges from .51 for perceived quality to .76 for trust, confirming convergent validity for all constructs. Perceived quality is the weakest construct in terms of reliability and AVE, whereas trust has the highest AVE. Trust is measured using two items with highly similar factor loadings ranging from .86 to .88.

Table 7

Results of the Tests of the Subhypotheses of Hypothesis 1 (Dependent Variable: Acceptance)

Hypothesis	Path	β	*t*	*p*	95% BCa CI	f^2	VIF	Result
H1a	PERF → ACC	0.18	2.90	.004	0.06–0.30	0.04	2.10	Supported
H1b	SERV → ACC	0.06	1.03	.302	-0.06–0.18	0.00	1.90	Rejected (CI includes zero)
H1c	RELI → ACC	0.15	2.34	.020	0.02–0.28	0.02	2.40	Supported
H1d	PQ → ACC	0.21	3.18	.002	0.08–0.34	0.04	2.60	Supported
H1e	AEST → ACC	0.04	0.73	.468	-0.07–0.15	0.00	1.70	Rejected (CI includes zero)
H1f	CONF → ACC	0.12	2.00	.047	0.00–0.24	0.02	1.80	Supported
H1g	FEAT → ACC	0.05	0.88	.381	-0.06–0.16	0.00	1.60	Rejected (CI includes zero)
H1h	DUR → ACC	0.10	1.69	.092	-0.02–0.22	0.01	2.20	Rejected (CI includes zero)
H1i	PR → ACC	0.19	3.11	.002	0.07–0.31	0.04	2.00	Supported
H1j	TRU → ACC	0.28	4.31	< .001	0.15–0.41	0.08	2.30	Supported

In Table 7, the columns report the standardized path coefficient (β), bootstrap *t* statistic and *p* value, 95% BCa confidence interval, effect size (f^2), variance inflation factor (VIF), and hypothesis-testing outcome. Of the 10

subhypotheses, six were supported (H1a, H1c, H1d, H1f, H1i, and H1j), whereas four were rejected (H1b, H1e, H1g, and H1h). Thus, Hypothesis 1 was partially supported. The strongest path was trust (β = .28, t = 4.31), followed by perceived quality (.21), perceived risk (.19), performance (.18), reliability (.15), and conformance (.12). The effect sizes for all paths were small, with the largest f^2 being .08 for trust and values of .04 for performance, perceived quality, and perceived risk. This indicates that each dimension makes a relatively small unique contribution to explaining acceptance and that the total explanatory effect results from the combination of multiple dimensions. The conformance path was at the threshold of statistical significance (p = .047), with the lower confidence-interval bound approximately equal to zero, and should therefore be interpreted cautiously. The rejected paths had small coefficients ranging from .04 to .10, with durability being the closest to significance (β = .10, p = .092). It should be noted that the relatively high mean perceptions of these dimensions reported in Table 2 are not inconsistent with their lack of unique structural effects because path coefficients represent the effect of each dimension while holding the other dimensions constant. VIF values for all predictors ranged from 1.60 to 2.60 and were below 3, indicating no problematic multicollinearity. Because perceived-risk items were reverse-coded, the positive perceived-risk coefficient indicates that lower perceived risk is associated with greater acceptance.

Table 8

Explanatory and Predictive Power of the Model

Index	Value	Criterion
R^2 (Acceptance)	0.58 (moderate)	0.25 = weak; 0.50 = moderate; 0.75 = substantial
Q^2 (Acceptance)	0.41 (> 0; satisfactory)	> 0
SRMR	0.061 (satisfactory)	< 0.08
PLSpredict (Q^2predict; RMSE comparison with linear model)	Q^2predict = 0.37; PLS model RMSE (0.71) was lower than linear-model RMSE (0.75) for all three ACC indicators; satisfactory out-of-sample predictive power	Q^2predict > 0 and RMSE lower than benchmark model
Company-level clustered bootstrap result	PQ, TRU, PERF, PR, and RELI remained significant under clustered bootstrapping; standard errors increased by approximately 12% on average; results were robust	Stability of path significance relative to conventional bootstrapping

In Table 8, R^2 = .58 indicates that the model explains 58% of the variance in acceptance, representing a moderate level according to commonly used thresholds. Q^2, calculated using the blindfolding procedure, was .41 and therefore greater than zero, confirming the predictive relevance of the model. The SRMR was .061, below the .08 threshold, indicating acceptable overall model fit (Hu & Bentler, 1999; Henseler et al., 2014). In the PLSpredict assessment, Q^2predict was positive (.37), and the RMSE of the PLS model was lower than that of the linear benchmark model for all three acceptance indicators, indicating strong out-of-sample predictive power (Shmueli et al., 2019). Under company-level clustered bootstrapping, standard errors increased by approximately 12% on average because of the clustered structure of the data; nevertheless, the PQ, TRU, PERF, PR, and RELI paths remained significant (Huang, 2018). The conformance path (H1f), which was only marginally significant under conventional bootstrapping, was not included among these robust paths and should therefore not be regarded as stable.

After establishing measurement invariance—at least partial measurement invariance corresponding to Steps 1 and 2 of the MICOM procedure (Henseler, Ringle, & Sarstedt, 2016)—the path coefficients were estimated separately for the three groups and compared using permutation tests (Table 9).

Table 9

Path Coefficients by Organizational Role and Between-Group Differences (Bonferroni-Adjusted Significance Level = .0167)

Path	β Owner	β Sales Manager	β Quality Manager	p (Owner–Sales)	p (Owner–Quality)	p (Sales–Quality)
PERF → ACC	0.12	0.17	0.25	.410	.070	.310
SERV → ACC	0.04	0.09	0.05	.520	.880	.600
RELI → ACC	0.10	0.14	0.21	.450	.120	.340
PQ → ACC	0.31	0.22	0.08	.280	.012*	.090

AEST → ACC	0.02	0.06	0.03	.640	.910	.700
CONF → ACC	0.09	0.13	0.15	.550	.370	.780
FEAT → ACC	0.07	0.04	0.06	.740	.890	.830
DUR → ACC	0.08	0.10	0.12	.690	.420	.770
PR → ACC	0.27	0.21	0.14	.500	.030	.220
TRU → ACC	0.24	0.30	0.31	.380	.290	.910

In Table 9, the first three columns report the path coefficient from each construct to acceptance for owners, sales managers, and quality managers, respectively, whereas the following three columns report permutation-test *p* values for each pairwise group comparison. Because three comparisons were performed, a difference was considered statistically significant only when $p < .0167$. The only significant difference was observed for the perceived quality path between owners ($\beta = .31$) and quality managers ($\beta = .08$), $p = .012$. The perceived risk path differed between owners (.27) and quality managers (.14), $p = .030$, only at the unadjusted .05 level and was no longer significant after correction. The difference in performance between owners and quality managers ($p = .070$) and all other comparisons were nonsignificant. Descriptively, perceived quality (.31 and .22) and perceived risk (.27 and .21) carried greater weight for owners and sales managers, whereas performance (.25), reliability (.21), and trust (.31) were more prominent for quality managers. Trust exhibited relatively similar coefficients across all three groups (.24–.31). Given the sample size of 71 observations in each group and the limited statistical power of the test, these patterns should be considered exploratory (Cheah et al., 2023). Overall, Hypothesis 2 was supported at the level of construct perceptions for nine of the 10 dimensions, whereas at the level of structural path strength it was supported for only one path. Accordingly, Hypothesis 2 was partially supported.

4 Discussion

The present study examined how Garvin's eight quality dimensions, together with perceived risk and trust, influence industrial customers' acceptance of an ethylene nano-adsorbent system for fruit and vegetable preservation. The findings provide a multidimensional view of technology acceptance in a B2B context by showing that industrial customers generally evaluated the technology positively, while simultaneously distinguishing between favorable perceptions of individual attributes and the actual predictive power of those attributes in the structural model. All ten dimensions scored significantly above the scale midpoint, indicating an overall positive orientation toward the technology. However, only six dimensions—trust, perceived quality, perceived risk, performance, reliability, and conformance—showed significant direct effects on acceptance. In contrast, serviceability, aesthetics, features, and durability did not exert significant unique effects once the other predictors were controlled. This pattern supports the view that B2B technology acceptance is not simply the result of favorable evaluations across multiple attributes, but rather depends on the relative importance of those attributes in reducing uncertainty and demonstrating value in an organizational purchasing setting (Bilro et al., 2023; Nyadzayo et al., 2020; Thanabodypath et al., 2021).

The descriptive findings showed that aesthetics, performance, and conformance received the highest mean evaluations. The strong score for performance is consistent with the logic of industrial adoption, because organizational buyers are primarily concerned with whether an innovation can deliver the functional outcomes for which it was acquired. In technology-intensive industrial markets, acceptance often depends on the perceived ability of an innovation to improve operational outcomes and create measurable value (Falkenreck et al., 2023; Thanabodypath et al., 2021). The high score for conformance similarly suggests that respondents perceived the nano-adsorbent system as compatible with expected specifications and usage requirements. This is important because B2B customers frequently evaluate value not only in terms of novelty but also in terms of whether the offering fits established operational processes, quality expectations, and organizational routines (Nandankar et al., 2023; Zou et al., 2021). The high score for aesthetics, while initially less expected in an industrial technology context, may reflect the importance of design, presentation, packaging, and visible product cues as heuristics that support broader quality judgments. Prior B2B research has shown that brand presentation and externally observable signals contribute to customers' perceptions of competence and value, especially where product attributes are not fully verifiable before purchase (Aagerup et al., 2022; Tjandra et al., 2020).

At the same time, perceived quality, durability, and serviceability received the lowest mean scores among the ten dimensions. These results are meaningful because they

indicate the areas in which industrial customers remain comparatively less convinced, despite their generally favorable perceptions of the technology. Lower perceived quality may reflect the novelty of nanotechnology and the limited availability of accumulated market experience, benchmarks, and long-term evidence. In B2B markets, perceived quality often emerges from a combination of prior experience, supplier credibility, brand image, and demonstrated performance rather than from technical claims alone (Fagundes et al., 2022; Kittur & Chatterjee, 2023). Likewise, lower durability evaluations may reflect uncertainty about how consistently the nano-adsorbent performs across storage conditions and over time. The relatively lower score for serviceability may indicate that customers have concerns about support, maintenance, guidance, or problem resolution associated with an emerging product. This is consistent with evidence showing that service performance and relationship management remain central to B2B value perceptions even when the core offering is technically sophisticated (Dung & Tu, 2023; Lasrado et al., 2022; Zou et al., 2021). It also corresponds with recent evidence that servitization and aftermarket activity may fail to strengthen repurchase intentions if customers perceive insufficient fairness or value in post-purchase support (Lin, 2026).

The one-sample *t* tests further confirmed that industrial customers held significantly positive perceptions across all dimensions. Large effect sizes for conformance, aesthetics, features, performance, trust, and perceived risk suggest that these favorable evaluations were not merely statistically detectable but substantively strong. The positive evaluation of perceived risk is particularly noteworthy because the scale was reverse-coded, meaning that higher scores indicate lower perceived risk. This result implies that respondents did not view the technology as excessively risky overall. Previous studies have shown that perceived risk is a critical factor in industrial purchasing because it shapes the extent to which customers are willing to commit financial and organizational resources to unfamiliar offerings (Kittur & Chatterjee, 2023; Wisnujati et al., 2024). Lower perceived risk may therefore reflect the extent to which respondents were able to understand the technology's intended function and perceive its benefits as credible. The finding also suggests that despite the novelty of nanotechnology, industrial customers may be relatively receptive when the application is directly associated with recognizable operational objectives such as reducing postharvest losses.

The significant differences among owners, sales managers, and quality managers provide another important contribution. Quality managers reported more favorable evaluations than owners across almost all dimensions, while sales managers generally occupied an intermediate position. This result indicates that industrial customers should not be treated as a homogeneous decision-making unit. B2B purchasing typically involves multiple organizational actors with distinct responsibilities, knowledge bases, and risk orientations (Bilro et al., 2023; Fergurson et al., 2024). Quality managers are likely to have greater familiarity with technical specifications, product consistency, quality-control processes, and performance criteria, which may make them more capable of interpreting the technology's functional characteristics and therefore more confident in its value. Owners, by contrast, may evaluate the same technology through a broader investment and strategic lens, where uncertainty about cost, market response, and financial consequences can reduce overall evaluations. The intermediate position of sales managers is also plausible because their role typically requires balancing technical feasibility with commercial acceptability and customer expectations.

The largest role-based differences were observed for perceived quality, durability, and performance, which further supports the importance of functional responsibility in shaping technology evaluations. Quality managers may have more direct access to evidence about product performance and conformance, whereas owners may rely more heavily on generalized impressions or supplier-provided information. B2B research shows that access to information, expertise, and relational interaction influences how customers form judgments about value and supplier capability (Lasrado et al., 2022; Saragih, 2024). In addition, social and digital channels may facilitate technical information exchange and thereby alter customer evaluations of complex offerings (Dwivedi et al., 2021; Itani et al., 2022). The absence of significant role differences in perceived risk is particularly notable. This suggests that concerns about safety and uncertainty may be shared more broadly across organizational roles rather than being confined to technically or commercially oriented managers. Such convergence may occur because risk is perceived as an organization-wide issue whose consequences could affect the entire firm.

The structural model identified trust as the strongest predictor of technology acceptance. This finding is theoretically consistent with B2B relationship research, in

which trust is repeatedly identified as a central mechanism for reducing uncertainty and facilitating commitment. In industrial exchanges, buyers often cannot fully verify the future performance of a technological offering before adoption and must therefore rely partly on confidence in the supplier's competence, intentions, and reliability (Rineggo et al., 2023; Rungsithong & Meyer, 2024). Trust is particularly important for nanotechnology because customers may not possess sufficient technical expertise to evaluate all aspects of the underlying material or process. Under such conditions, supplier trust can function as a substitute for incomplete knowledge and reduce the psychological burden of adoption. This finding also aligns with research showing that strong B2B relationships are sustained by trust, relational quality, and value co-creation rather than by product performance alone (Lasrado et al., 2022; Saragih, 2024). It additionally supports the view that a competent and credible B2B brand can reduce customer uncertainty and facilitate favorable evaluations (Aagerup et al., 2022).

Perceived quality was the second strongest predictor of acceptance, confirming that customers' global evaluation of product superiority is particularly influential when they are considering an unfamiliar technology. This result is consistent with evidence that perceived product quality can affect repurchase behavior directly and indirectly through perceived risk (Wisnujati et al., 2024). It also aligns with research showing that brand image and supplier reliance help reduce perceived risk and shape purchasing responses in B2B settings (Kittur & Chatterjee, 2023). The significance of perceived quality suggests that industrial customers may synthesize multiple technical and relational cues into a broader judgment regarding whether the nano-adsorbent system is a "high-quality" solution. This may be especially important when buyers cannot independently validate all technical attributes. In this sense, perceived quality functions as an integrative evaluative mechanism rather than merely one attribute among many.

Perceived risk also exerted a significant positive effect on acceptance, remembering that the measure was reverse-coded. Thus, lower perceived risk was associated with higher acceptance. This result is highly consistent with the logic of organizational purchasing, where uncertainty can discourage adoption even when potential benefits are substantial. Previous studies have shown that perceived risk mediates or conditions the relationship between product evaluations and repurchase intentions (Wisnujati et al., 2024), while reliance on credible suppliers and strong brand image can reduce risk perceptions (Kittur & Chatterjee, 2023). In the context of nanotechnology, perceived risk may involve uncertainty about safety, effectiveness, compatibility, and customer reactions. The significant effect of risk reduction therefore implies that adoption is facilitated when suppliers communicate credible evidence, clarify applications, and reduce uncertainty regarding the consequences of implementation. Ethical transparency can reinforce this process because responsible conduct and clear communication strengthen confidence in interorganizational relationships (Anand et al., 2023; Bag et al., 2023).

Performance and reliability were also significant predictors of acceptance, reinforcing the centrality of functional value in industrial markets. These findings are consistent with industrial innovation research, where buyers prioritize technologies that demonstrate reliable performance and clear operational benefits (Thanabodypath et al., 2021). Performance reflects whether the system achieves its intended purpose, whereas reliability captures whether it can do so consistently. For an ethylene nano-adsorbent system, these dimensions are directly connected to expected reductions in deterioration and improved storage outcomes. B2B service and technology research similarly indicates that competence-based performance strongly influences relationship value and customer responses (Zou et al., 2021). The fact that both performance and reliability retained significant effects in the multivariate model suggests that industrial customers distinguish between the level of functional benefit and the consistency with which that benefit can be delivered.

Conformance was significant only marginally in the standard bootstrap analysis and did not remain robust under company-level clustered bootstrapping. This suggests that its effect should be interpreted cautiously. Conceptually, conformance should matter because organizational customers often need technologies to fit specifications, standards, and operating procedures. However, its weak and unstable effect may indicate that once broader perceptions of quality, reliability, and performance are considered, conformance contributes little additional explanatory power. This result illustrates an important distinction between favorable descriptive evaluations and unique predictive effects. A dimension may receive a high mean score while failing to predict acceptance independently because its explanatory variance overlaps with other quality dimensions. This pattern is consistent with multidimensional models of B2B value in which several interrelated attributes

contribute jointly to customer judgments (Dung & Tu, 2023; Nandankar et al., 2023).

In contrast, serviceability, aesthetics, features, and durability did not significantly predict acceptance in the structural model. These nonsignificant paths do not indicate that these dimensions are irrelevant; rather, they suggest that they do not add substantial unique explanatory power once trust, perceived quality, perceived risk, performance, reliability, and conformance are taken into account. Aesthetics and features may be appreciated by customers but may be secondary in a high-involvement industrial purchase where the key concerns involve functional performance, safety, and credibility. Similarly, serviceability and durability may affect longer-term satisfaction or repurchase rather than initial technology acceptance. Prior B2B research has shown that some relationship and service variables become especially salient after customers accumulate experience with the offering (Lee et al., 2022; Oflaç et al., 2021). The relatively weaker role of these dimensions may therefore reflect the stage of adoption examined in this study rather than their general lack of importance.

The model explained 58% of the variance in acceptance and demonstrated satisfactory predictive relevance and out-of-sample predictive power. These results indicate that the integration of quality and psychological variables provides a meaningful explanation of industrial technology acceptance. This supports the broader B2B literature suggesting that customer behavior is shaped by a combination of functional, relational, psychological, and informational mechanisms (Bilro et al., 2023; Nyadzayo et al., 2020). The favorable predictive performance also indicates that the model is not limited to explaining the observed sample but has practical potential for predicting acceptance in similar organizational contexts. The stability of most key paths under company-level clustered bootstrapping further strengthens confidence in the results, particularly for trust, perceived quality, perceived risk, performance, and reliability.

5 Conclusion

The multigroup results showed that most structural relationships were statistically similar across organizational roles, despite substantial differences in mean perceptions. Only the effect of perceived quality differed significantly between owners and quality managers after Bonferroni correction. Perceived quality exerted a stronger effect on acceptance among owners, whereas its effect was relatively weak among quality managers. This result is conceptually plausible because owners may rely more strongly on holistic product evaluations when making adoption decisions, while quality managers may depend more on specific technical indicators such as reliability and performance. This interpretation is consistent with the idea that organizational actors use different informational cues depending on their responsibilities and expertise. The result also supports B2B research emphasizing that value judgments are role-dependent and embedded in organizational relationships rather than purely individual preferences (Fergurson et al., 2024; Saragih, 2024). Although the perceived-risk path also differed between owners and quality managers at the conventional .05 level, it did not remain significant after multiple-comparison correction and should therefore be treated as exploratory.

This study has several limitations. First, its cross-sectional design restricts causal interpretation because all perceptions and acceptance measures were collected at a single point in time. Second, the sample was drawn from companies operating in the fruit supply chain in Iran, which may limit the generalizability of the results to other industries, countries, or institutional settings. Third, although 213 responses were adequate for the overall PLS-SEM analysis, the subgroup size of 71 respondents per organizational role provided limited statistical power for multigroup comparisons. Fourth, three respondents were sampled from each company, creating a clustered data structure; although company-level bootstrapping was used as a robustness check, residual dependence may remain. Fifth, the study relied on self-reported questionnaire data and may therefore be affected by common method variance, social desirability, and subjective interpretation of technical concepts. Sixth, some constructs were measured with relatively few items, particularly trust with two indicators, which limits the breadth of construct representation. Finally, the study focused on intention and acceptance-related evaluations rather than objectively observed purchasing behavior, actual technology use, or longitudinal repurchase decisions.

Future studies should use longitudinal designs to examine how industrial customers' perceptions change before adoption, during implementation, and after experience with the technology. Replication in other agricultural, food-processing, logistics, packaging, and manufacturing industries would help establish the external validity of the model. Future research should also employ larger samples at the organizational-role level so that differences among owners, technical managers, purchasing managers, sales

managers, and other decision makers can be tested with greater statistical power. Multilevel models could explicitly separate individual-level perceptions from company-level influences and more fully account for nested data structures. Researchers may also expand the model by examining price, perceived value, compatibility, environmental benefits, regulatory assurance, supplier reputation, technology readiness, and organizational innovativeness. Experimental studies could manipulate product labeling, technical information, safety communication, certification, and demonstrations to identify which communication strategies most effectively reduce perceived risk and increase trust. In addition, future research should distinguish initial adoption from continued use, satisfaction, loyalty, and repurchase, because quality dimensions that were nonsignificant at the adoption stage may become important after prolonged product experience.

Managers and vendors commercializing ethylene nano-adsorbent systems should prioritize trust building, perceived quality, risk reduction, performance evidence, and reliability because these factors showed the strongest relationships with acceptance. Communication should be tailored to organizational roles rather than delivered uniformly to all members of a customer organization. Owners should receive clear evidence regarding overall product quality, economic value, operational risk, and expected return from adoption, whereas quality managers should be provided with detailed technical information, performance validation, reliability data, and conformity evidence. Sales managers should receive information that connects technical benefits with customer-facing and commercial advantages. Vendors should also address the comparatively weaker perceptions of durability and serviceability through warranties, technical support, implementation guidance, troubleshooting procedures, and clear after-sales commitments. Product labeling should state the role of nanotechnology in a transparent and understandable manner and should directly address safety-related concerns. Demonstrations, pilot applications, independent test results, and credible performance documentation can further reduce uncertainty and strengthen acceptance. Finally, suppliers should recognize that favorable perceptions of product features or aesthetics alone are insufficient; successful commercialization requires an integrated strategy that combines demonstrable technical performance with credible communication, transparent risk management, and sustained relationship-based trust.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

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