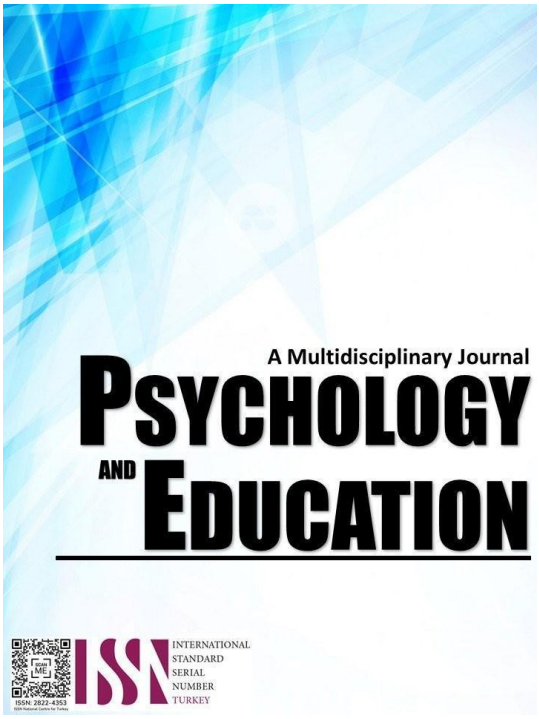
THE DESIGN OF AN ENHANCED SUPPLIER EVALUATION SYSTEM FOR THE RUBBER CHEMICALS INDUSTRY



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esearch Article

The Design of an Enhanced Supplier Evaluation System for the Rubber Chemicals Industry

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Abstract

This study presents the design and qualitative evaluation of an enhanced supplier evaluation system tailored to the rubber chemicals industry. In response to the limitations of traditional models that often overemphasize cost and delivery metrics, the study adopts the ADDIE instructional design framework to develop a context-specific, multidimensional assessment tool. Drawing from qualitative data collected through focus group discussions and expert interviews across 35 rubber chemical firms in China, the research identifies key evaluation dimensions including product quality standards, quality control systems, cost transparency, logistics performance, and on-time delivery. The findings emphasize the increasing importance of supplier responsiveness, environmental accountability, and strategic alignment in supplier selection processes. Thematic analysis reveals a strong preference for transparent pricing structures, collaborative quality management, and digital procurement integration. Compared to previous models, the proposed system offers a more holistic and adaptive approach to supplier evaluation, aligned with industry-specific operational demands and sustainability objectives. The study contributes a practical framework for supplier assessment that supports improved decision-making, long-term collaboration, and enhanced supply chain performance.

Keywords: *supplier evaluation, rubber chemicals industry, ADDIE model, qualitative research, supply chain management, fuzzy logic, cost transparency, logistics performance*

Introduction

In the rubber chemicals industry, supplier evaluation plays a pivotal role in ensuring the consistency, sustainability, and competitiveness of production processes. The increasing complexity of global supply chains, heightened environmental regulations, and intensifying market demands underscore the need for robust and adaptive supplier evaluation frameworks (Neely et al., 2002). While conventional models such as the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) have been widely utilized (Luo & Peng, 2011; Huang & Wang, 2013), these methods often fall short in capturing the multifaceted and dynamic criteria necessary in the modern rubber chemicals landscape.

Existing solutions typically emphasize cost, quality, and delivery performance (Weber et al., 2001), yet lack sufficient integration of sustainability metrics, developmental capabilities, and real-time adaptability. Among these, the fuzzy comprehensive evaluation method stands out for its ability to handle uncertainty and imprecise information (Wen & Feng, 2004). However, its implementation often remains fragmented and not fully aligned with systematic instructional design principles or evolving industrial expectations (Omurca, 2018).

The main limitation of current models is their limited responsiveness to contextual shifts, such as environmental pressures and the digitalization of procurement processes (Wiśniewska et al., 2024). They also seldom incorporate stakeholder feedback mechanisms that support continuous improvement and strategic alignment with industry goals (Bititci et al., 2012).

This study aims to address these gaps by designing and evaluating an enhanced supplier evaluation system for the rubber chemicals industry using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model. Embedding fuzzy logic into a systematic design framework, this research aspires to deliver a more holistic, adaptable, and industry-relevant evaluation tool that enhances supplier assessment, promotes strategic collaboration, and strengthens the sustainability and resilience of supply chains.

Methodology

Research Design

This study employed a developmental evaluation design guided by the ADDIE model Analysis, Design, Development, Implementation, and Evaluation. The ADDIE framework, originally designed for instructional systems development, provides a systematic, iterative process for designing, testing, and refining complex systems (DeBell, 2020). The model was adapted to structure the development of an enhanced supplier evaluation system tailored to the rubber chemicals industry.

Operationalized through an input-process-output framework, the research commenced with an in-depth analysis of the existing supplier

evaluation system (input). This was followed by iterative phases of design, development, and pilot implementation (process), culminating in the creation and assessment of the enhanced evaluation system (output). The integration of the ADDIE model ensured systematic progression and adaptability across all research phases.

Respondents

Participants were drawn from 35 leading firms within the Chinese rubber chemicals industry, selected through purposive sampling. Respondents included procurement officers, quality assurance specialists, and industry experts directly involved in supplier management and evaluation. The evaluation phase incorporated both process and product assessments. Process data were obtained through participant feedback during system implementation, while product data were collected via expert reviews and user ratings of the system's functionality and usability.

Additionally, a focus group discussion (FGD) was conducted with ten volunteer participants to elicit qualitative feedback, refine evaluation criteria, and identify emergent themes relevant to industry practices. This multi-source engagement ensured both practical relevance and triangulation of findings.

Instrument

To capture rich, context-specific insights, a semi-structured qualitative instrument was developed based on the core dimensions of supplier evaluation relevant to the rubber chemicals industry. The interview guide included open-ended prompts exploring supplier quality management, responsiveness, pricing transparency, logistics performance, and delivery reliability. The guide was validated by industry experts to ensure content relevance and clarity. Focus was placed on eliciting narratives that reveal underlying practices, perceptions, and improvement needs related to supplier evaluation.

In addition, a Focus Group Discussion (FGD) protocol was designed to facilitate collective reflection and stakeholder dialogue among selected participants who experienced the pilot implementation of the enhanced evaluation system. The instrument encouraged participants to share operational challenges, supplier experiences, and strategic recommendations.

Procedure

Data collection was conducted over a four-month period (January to April 2025) across 35 leading rubber chemical companies in China. Respondents were purposively selected based on their involvement in procurement, supplier evaluation, or quality assurance functions. A total of 10 key informants participated in the FGDs, while additional qualitative feedback was gathered through in-depth interviews with industry stakeholders.

All interviews and discussions were conducted in either Mandarin or English, depending on participant preference, and were audio-recorded with informed consent. Transcriptions were produced verbatim and translated as needed for analysis. Field notes and reflexive memos were also maintained to capture contextual nuances and researcher observations throughout the process.

Data Analysis

A thematic analysis approach was employed to interpret the qualitative data, following Braun and Clarke's six-phase process: (1) familiarization with the data, (2) generation of initial codes, (3) identification of patterns, (4) development of themes and subthemes, (5) refinement of themes, and (6) production of a coherent narrative.

Transcripts were coded inductively, with emergent themes representing recurring supplier evaluation concerns and improvement opportunities. Data were managed and organized using qualitative analysis software, and codes were cross-validated by a second researcher to ensure credibility and minimize interpretive bias. The themes derived were used to inform the final design and refinement of the enhanced supplier evaluation system.

Ethical Considerations

The study adhered to ethical research principles, ensuring informed consent, anonymity, and data confidentiality. Ethical clearance was secured prior to data collection. The selection of evaluation indicators was governed by five guiding principles: comprehensiveness, independence, universality, feasibility, and relevance to stakeholder interests. These principles were derived from industry-specific literature and stakeholder consultations to ensure fairness and validity in supplier assessment.

Results and Discussion

Main Category	*Theme*	*Subtheme*
Product Quality	Establishment of Quality Standards	
	Continuous Improvement and Training	
Product Continuous Improvement	Establishment of a Quality Management System	
	Supplier Response	

Quality Control System	Supplier Quality Management	
	Enhance Market Competitiveness	
Price Competitiveness	Cost Transparency	Pricing Structure on the Cooperative Relationship
	Cost Transparency	Use of Digital Intelligence Procurement System
Cost Transparency	Providing Cost Structure	Market Research
	Providing Cost Structure	Transparency Improvement
	Communication of Changes in Cost or Pricing Adjustments	Formal Notification Letter
	Communication of Changes in Cost or Pricing Adjustments	Telephone Conference or Face-to-Face Meeting
	Communication of Changes in Cost or Pricing Adjustments	Market Announcement
Logistics Cost	Impact on the Overall Budget	Cost Control and Budget Optimization
	Impact on the Overall Budget	Price Negotiation and Budget Control
	Impact on the Overall Budget	Risk Management and Budget Stability
	Impact on Service Satisfaction	Efficiency and Quality of Logistics Service
	Impact on Service Satisfaction	Customized Service and Satisfaction Improvement
	Impact on Service Satisfaction	Long-Term Cooperation and Trust Building
	Impact on Service Satisfaction	Effective Communication of Logistics Cost Components
On-Time Delivery	Ability to Deliver Products	Reduce Supply Chain Disruption
	Ability to Deliver Products	Optimize Inventory Management
	Improvement in Delivery Performance	Improved Accuracy of Delivery Time
	Improvement in Delivery Performance	Faster Response
	Improvement in Delivery Performance	Technological Innovation and Application
	Improvement in Delivery Performance	Customer Service and Satisfaction Improvement
	Improvement in Delivery Performance	Environmental and Social Responsibility
	Improvement in Delivery Performance	Enhanced Risk Management Capability

The thematic analysis of focus group discussions and expert interviews with procurement professionals from 35 rubber chemical enterprises in China revealed seven principal categories that characterize the current practices and priorities in supplier evaluation. These categories reflect the industry's evolving emphasis on strategic alignment, transparency, and operational responsiveness.

Under the domain of Product Quality, two dominant themes emerged. The Establishment of Quality Standards was identified as a fundamental criterion, wherein participants highlighted the necessity of harmonized specifications, audit procedures, and objective quality benchmarks. Alongside this, Continuous Improvement and Training was emphasized as essential for long-term supplier development, with respondents citing training programs, technical collaboration, and iterative quality reviews as mechanisms to build supplier capability.

In the area of Product Continuous Improvement, the presence of a formal Quality Management System was noted as a strategic requirement. Such systems typically involved documentation, compliance tracking, and corrective protocols. Furthermore, Supplier Response the supplier's capacity to integrate feedback and swiftly adapt to changing technical and market demands was widely considered a critical determinant of continued supplier engagement.

For the Quality Control System, two themes dominated: Supplier Quality Management, which encompassed internal inspection processes, traceability, and defect prevention measures, and Enhancement of Market Competitiveness, where superior quality performance was directly linked to the buying firm's product differentiation and customer satisfaction.

Regarding Price Competitiveness, Cost Transparency emerged as a key theme. Subthemes included a well-defined Pricing Structure based on cooperative relationships, and the Use of Digital Intelligence Procurement Systems to facilitate real-time pricing analysis, supplier benchmarking, and negotiation efficiency.

The broader category of Cost Transparency revealed a more nuanced view. The theme of Providing Cost Structure incorporated Market Research and Transparency Improvement, where suppliers disclosed component-level costs and cost drivers. Another theme, Communication of Changes in Cost or Pricing Adjustments, comprised varying methods such as Formal Notification Letters, Telephone or Face-to-Face Meetings, and Market Announcements, each reflecting different levels of formality and strategic intent.

Within the Logistics Cost category, two themes were delineated. The Impact on the Overall Budget included subthemes such as Cost Control and Budget Optimization, Price Negotiation and Budget Control, and Risk Management and Budget Stability, all of which were considered vital to procurement planning and financial predictability. The second theme, Impact on Service Satisfaction, was illustrated through subthemes like Efficiency and Quality of Logistics Services, Customized Service and Satisfaction Improvement, Long-Term Cooperation and Trust Building, and Effective Communication of Logistics Cost Components.

Finally, the category of On-Time Delivery encapsulated concerns related to reliability and performance. The theme Ability to Deliver Products was articulated through efforts to Reduce Supply Chain Disruption and Optimize Inventory Management. The theme Improvement in Delivery Performance included six subthemes: Improved Accuracy of Delivery Time, Faster Response, Technological Innovation and Application, Customer Service and Satisfaction Improvement, Environmental and Social Responsibility, and Enhanced Risk Management Capability. These findings reflect an industry-wide transition from transactional supplier relationships to strategic partnerships rooted in performance, innovation, and mutual value creation.

Conclusions

This study advances the field of supplier evaluation by proposing and qualitatively validating an enhanced evaluation framework tailored to the specific operational, economic, and regulatory context of the rubber chemicals industry. Building upon the limitations of existing models that overemphasize cost and delivery metrics (Weber et al., 2001; Wang & Xing, 2008), this research integrates multifaceted dimensions including supplier responsiveness, pricing transparency, environmental accountability, and logistics service quality within the structure of a developmental ADDIE model.

Unlike prior studies that focused largely on quantitative optimization or rigid performance indicators (Omurca, 2018; Zhu & Sarkis, 2004), this work contributes a contextual, process-oriented approach that centers on continuous improvement, strategic alignment, and relational value creation. The themes uncovered ranging from quality standardization to digital procurement intelligence reflect a shift in how supplier value is conceptualized, particularly in sectors where product integrity, regulatory compliance, and long-term trust are paramount.

By grounding the design and evaluation process in participant experiences and stakeholder feedback, the study introduces a practical and adaptive framework that can be used not only for supplier assessment but also for supplier development and partnership cultivation. This framework offers a reference model for supply chain managers seeking to operationalize supplier criteria in alignment with evolving market demands and sustainability goals.

Future studies should focus on quantifying the weight and impact of each identified dimension using hybrid modeling techniques (e.g., fuzzy AHP or DEMATEL) and test the model's applicability across different manufacturing sectors. Furthermore, longitudinal studies could examine how implementation of the proposed system influences procurement outcomes, supplier innovation, and organizational resilience over time.

This study does not merely refine supplier evaluation it repositions it as a dynamic, strategic, and participatory process. Its contribution lies in offering a holistic, empirically grounded, and industry-responsive evaluation system that can support more informed, agile, and collaborative supply chain decisions.

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