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Developing an Evidence-Based Ppap Approval Capability Framework for Supplier Competitiveness: Evidence from Malaysian Automotive Manufacturing

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Abstract

Production Part Approval Process (PPAP) is one of the important automotive industry quality management processes that enables suppliers to ensure that their process is meeting customer specification. There are not many empirically-based organisational capability frameworks that are available when it comes to translating PPAP practices. The purpose of this study is to develop an Evidence based PPAP Approval Capability Framework which aims to evaluate the competitiveness of suppliers in the Malaysian auto industry using PPAP. A preliminary framework was developed based on the literature and validated in the responses to the questionnaire from 88 Malaysian automotive manufacturing organisations. Cronbach's alpha was used for measuring the reliability of measurements and Spearman's rank-order correlation was used for establishing the validity of the proposed relationships at the level of $\rho \geq 0.60$ and $p < 0.01$. The three relationships were validated. The highest correlation was found between PPAP documentation integration and supplier quality data capture ($\rho = 0.742$, $p < 0.01$); and PPAP management control and supplier documentation practices with standard reaction plans for incapable processes ($\rho = 0.630$ and $\rho = 0.621$, respectively; $p < 0.01$). No proposed relationship between PPAP Approval Capability and OEE was found that met the validation criterion. The study has an evidence-based capability framework to improve the PPAP practices that will make the suppliers more competitive in the automotive manufacturing industry in Malaysia.

Keywords: PPAP Approval Capability, Supplier Competitiveness, Organisational Capability, Evidence-Based Framework, Automotive Manufacturing, Malaysia

Introduction

Supplier competitiveness in the automotive industry increasingly depends on consistent quality, process reliability, and the ability to meet customer requirements (Porter, 1985; Flynn et al., 1995). The Production Part Approval Process (PPAP) provides a structured mechanism for suppliers to demonstrate product and process compliance through documentation, process controls, capability studies, and supplier quality information (Belu et al., 2013; Kumar Singh & Modgil, 2023). This is particularly relevant in the Malaysian automotive industry, where structured supplier development and quality practices support manufacturer–supplier relationships (Abdullah et al., 2008; Suhaime et al., 2024).

Despite the established role of PPAP, its organisational capability dimension remains insufficiently understood. Previous studies have examined PPAP in relation to quality assurance, process control, and supplier quality practices (Belu et al., 2013; Salimian et al., 2020; Kumar Singh & Modgil, 2023), but limited empirical evidence identifies which specific PPAP practices are associated with different supplier performance outcomes. In particular, the relationships involving PPAP documentation integration and management control require further empirical examination. This creates a gap in translating PPAP practices into an evidence-based organisational capability framework.

Accordingly, this study develops and validates an Evidence-Based PPAP Approval Capability Framework for Malaysian automotive manufacturing organisations. The study empirically examines relationships between PPAP Approval Capability and Supplier Quality Performance, Quality Performance, and Overall Equipment Effectiveness, and retains relationships that satisfy the predefined validation criteria. The resulting framework identifies PPAP practices supported by empirical evidence within the Malaysian automotive context.

Literature Review

Supplier Competitiveness in Automotive Manufacturing

Supplier competitiveness refers to the ability of suppliers to maintain a competitive position while consistently meeting customer requirements through quality, delivery, cost, responsiveness, process capability, and collaboration (Porter, 1985; Flynn et al., 1995; Abdullah & Maharjan, 2003). These dimensions are interrelated, and competitiveness depends not only on operational efficiency but also on organisational capabilities to coordinate supplier activities, maintain process stability, adapt to customer requirements, and continuously improve. This capability dimension is particularly important in automotive supply chains, where suppliers are increasingly involved in product development, engineering, process improvement, and quality assurance, supported by closer manufacturer–supplier relationships and capability development (Mohamad et al., 2015; Abdullah et al., 2008). Recent research also emphasises the multi-dimensional nature of supplier performance and the relevance of capability-based frameworks for understanding organisational practices and supplier competitiveness (Titu et al., 2025; Wan Mahmood et al., 2026). From this perspective, PPAP Approval Capability represents a quality-related organisational capability that reflects the supplier's ability to understand customer

requirements and consistently demonstrate manufacturing capability prior to formal part acceptance.

PPAP Approval Capability

Production Part Approval Process (PPAP) provides a structured approach for demonstrating that products and manufacturing processes meet customer requirements before production approval (Belu et al., 2013; Kumar Singh & Modgil, 2023). PPAP involves the management of product and process documentation, process controls, capability studies, and supplier information. In this study, PPAP Approval Capability is therefore conceptualised as the organisational capability to manage and integrate these PPAP-related activities to support product and process approval.

PPAP Approval Capability and Supplier Competitiveness

PPAP Approval Capability may be associated with supplier competitiveness through quality assurance, risk management, process control, and structured information management. Effective PPAP practices require the identification of process risks, establishment of controls and reaction plans, assessment of process capability, and systematic management of supplier quality information (Belu et al., 2013; Salimian et al., 2020; Mohd. Ali, 2020). These practices may support Supplier Quality Performance and Quality Performance by enabling organisations to identify process weaknesses, manage quality information, and respond systematically to processes that do not meet requirements. However, PPAP primarily focuses on product and process approval, whereas Overall Equipment Effectiveness (OEE) is influenced by equipment availability, performance, maintenance, reliability, and production scheduling (Rahman et al., 2022; Fuad et al., 2025). Thus, the relationship between PPAP Approval Capability and supplier performance may differ across performance dimensions. This distinction provides the basis for empirically examining the three proposed relationships in this study

Development of the Preliminary PPAP Approval Capability Framework

Based on the preceding literature, a preliminary PPAP Approval Capability Framework was developed to examine the relationships between PPAP Approval Capability and three dimensions of supplier performance: Supplier Quality Performance, Quality Performance, and Overall Equipment Effectiveness. The framework serves as a conceptual basis for empirical validation rather than assuming that all proposed relationships are supported. Each relationship is evaluated using data from Malaysian automotive manufacturing organisations and is retained or excluded according to the predefined validation criteria. Figure 1 presents the preliminary PPAP Approval Capability Framework.

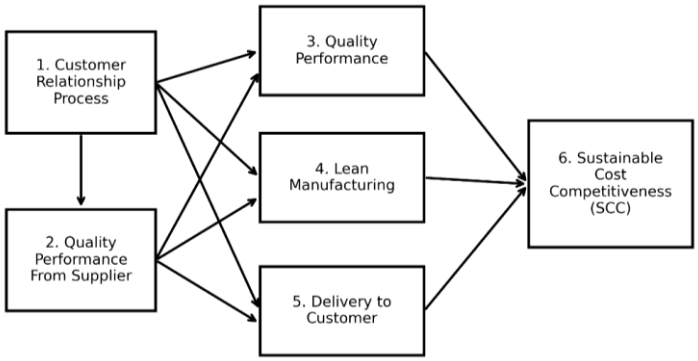

Figure 1 Preliminary PPAP Approval Capability Framework

Methodology

Research Design

This study developed and validated an Evidence-Based PPAP Approval Capability Framework using a quantitative, cross-sectional design. The study adopted a framework-building approach in which an initial conceptual framework was refined based on empirical evidence rather than solely on theoretical relationships.

Four steps were involved: (1) developing a preliminary framework through a literature review; (2) developing the measurement constructs and questionnaire; (3) empirically validating the proposed relationships using data from Malaysian automotive manufacturing organisations; and (4) integrating the validated relationships into the final evidence-based framework. This approach is shown in Figure 2.

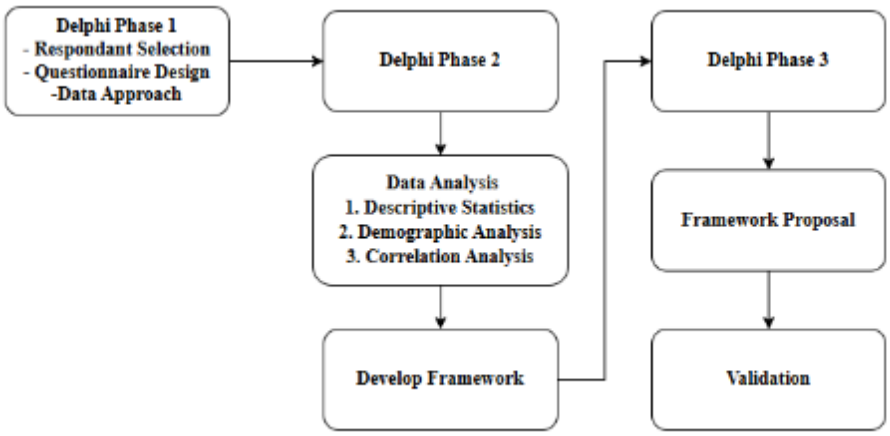

Figure 2 Framework Development Methodology

The methodology provides a systematic transition from theoretical reasoning to empirical evidence. The proposed relationships were identified from the literature, while the empirical analysis determined which relationships met the predefined criteria for inclusion in the final framework. Rather than retaining all proposed relationships based solely on conceptual reasoning, this approach supports systematic framework development and refinement (Okoli & Pawlowski, 2004; Beiderbeck et al., 2021).

Measurement Constructs

PPAP Approval Capability (PA), Quality Performance (QP), Supplier Quality Performance (QPS), and Overall Equipment Effectiveness (OEE) were the four main constructs of the questionnaire. The organizational capacity to oversee PPAP planning, documentation, control systems, and supplier integration is represented by PPAP Approval Capability. While Quality Performance displays organizational outcomes linked to process capabilities and quality control, Supplier Quality Performance shows the supplier's capacity to consistently satisfy customer quality criteria. OEE stands for equipment effectiveness in terms of performance, quality, and availability.

A five-point Likert scale was used to rate each item. The questionnaire created for the thesis served as the basis for the measurement constructs, which were then contextualized to the Malaysian automobile manufacturing setting (Flynn et al., 1995; Belu et al., 2013). The structures, number of elements, measurement scale, and operational descriptions are shown in Table 1.

Table 1
Measurement Constructs Used for Empirical Framework Validation

Construct	Description	No. of Items	Measurement Scale
PPAP Approval Capability (PA)	Organisational capability for managing PPAP documentation, planning, control systems, and supplier integration	4	Five-point Likert Scale
Supplier Quality Performance (QPS)	Supplier performance in consistently meeting customer quality requirements	3	Five-point Likert Scale
Quality Performance (QP)	Organisational quality performance encompassing process capability and quality control	9	Five-point Likert Scale
Overall Equipment Effectiveness (OEE)	Equipment effectiveness encompassing availability, performance, and quality	4	Five-point Likert Scale

The four components allow the study to determine associations that satisfy the predetermined empirical validation criteria and to investigate if PPAP Approval Capability is related to various aspects of supplier performance.

Data Collection

The study focused on Malaysian automakers who are part of the country's automotive supply chain. The respondents, who provided pertinent organizational knowledge for evaluating PPAP implementation and supplier performance, included managers and senior staff engaged in manufacturing, quality management, PPAP activities, and related operational responsibilities (Abdullah et al., 2008; Mohamad et al., 2015).

The chosen respondents were given a systematic questionnaire, and 88 valid answers were obtained. The responding organizations represented a range of organizational scales and market orientations in terms of production capacity utilization, yearly sales, workforce size,

and export activity. The demographic profile of the responding organizations is shown in Table 2.

Table 2
Demographic Profile of Responding Organisations (n = 88)

Organisational Characteristic	Category	Percentage (%)
Production Capacity Utilisation	Below 60%	17.0
	60–70%	22.7
	71–80%	31.8
	81–90%	22.7
	Above 90%	5.7
Annual Sales	Below RM10 million	3.4
	RM10–50 million	36.4
	RM51–100 million	21.6
	Above RM100 million	38.6
Number of Employees	Below 100	19.3
	100–200	39.8
	201–300	10.2
	301–400	4.5
	Above 400	26.1
Export Activity	Yes	43.2
	No	56.8

The sample includes businesses with varying organizational sizes and degrees of industrial activity. While annual sales and labor size varied widely, production capacity utilization was focused between 60% and 90%. When assessing PPAP Approval Capability among Malaysian automotive suppliers, the inclusion of both exporting and non-exporting organizations offers further diversity in market orientation.

Reliability Assessment

Cronbach's alpha was used to assess the internal consistency of the four measurement constructs before empirical relationship validation (Nunnally & Bernstein, 1994). Table 3 presents the reliability results.

Table 3
Reliability Assessment of the Measurement Constructs

Construct	No. of Items	Cronbach's Alpha	Interpretation
PPAP Approval Capability (PA)	4	0.910	Excellent reliability
Supplier Quality Performance (QPS)	3	0.528	Acceptable for exploratory research*
Quality Performance (QP)	9	0.654	Acceptable reliability
Overall Equipment Effectiveness (OEE)	4	0.776	Acceptable reliability

*Cronbach's alpha values above 0.50 are generally considered acceptable for exploratory organisational research, particularly where constructs comprise a limited number of measurement items (Nunnally & Bernstein, 1994).

The findings show satisfactory consistency for OEE (α = 0.776) and strong internal consistency for PPAP Approval Capability (α = 0.910). While Supplier Quality Performance reported a lower coefficient (α = 0.528), Quality Performance showed moderate internal consistency (α = 0.654). Because the study used an exploratory framework construction technique and the construct has just three items, Supplier Quality Performance was kept in spite of this restriction. With the reduced reliability of Supplier Quality Performance accepted as a methodological restriction, the reliability findings thus offer enough foundation to move forward with the ensuing empirical relationship analysis.

Empirical Validation

The suggested connections between PPAP Approval Capability and the three supplier performance metrics were assessed using Spearman's rank-order correlation analysis. Without depending on the presumptions necessary for parametric correlation processes, Spearman's correlation was chosen to investigate relationships involving ordinal responses evaluated using a five-point Likert scale.

A predefined validation criterion of Spearman's $\rho \geq 0.60$ and $p < 0.01$ was applied to determine whether each proposed relationship was sufficiently supported for inclusion in the final framework. Relationships meeting both conditions were retained, whereas relationships failing to meet either condition were excluded.

The criterion served as a framework development decision rule rather than solely a test of statistical significance. This distinction ensures that relationships included in the final framework demonstrate both statistical significance and a minimum level of association strength. The approach is consistent with systematic evidence-based framework development and refinement (Okoli & Pawlowski, 2004; Beiderbeck et al., 2021).

Results

PPAP Approval Capability and Supplier Quality Performance

The first proposed relationship examined the association between PPAP Approval Capability and Supplier Quality Performance. Table 4 presents the empirical validation results.

Table 4
Empirical Validation of PPAP Approval Capability and Supplier Quality Performance

PPAP Approval Capability Item	Supplier Quality Performance Item	Spearman's ρ	Significance	Framework Decision
PA3 – Supplier PPAP documentation is reviewed and incorporated in PPAP submissions	QPS1 – Supplier quality data captured for each BOM item	**0.742**	p < 0.01	**Retained**

Framework Validation Criterion: Spearman's ρ ≥ 0.60 (p < 0.01)

The relationship between PA3 and QPS1 produced a Spearman's correlation coefficient of 0.742 ($p < 0.01$), satisfying the predefined framework validation criterion. The coefficient indicates a strong positive association between the review and integration of supplier PPAP documentation and the capture of supplier quality data for each Bill of Materials (BOM) item.

This finding suggests that systematic integration of supplier PPAP documentation is associated with improved availability of component-level quality information for review and quality decision-making. The result is consistent with the role of PPAP in integrating supplier information and supporting evidence of manufacturing capability (Belu et al., 2013; Kumar Singh & Modgil, 2023), as well as the importance of information integration in automotive supplier relationships (Mohamad et al., 2015).

Accordingly, the PA3–QPS1 relationship was retained in the Evidence-Based PPAP Approval Capability Framework.

PPAP Approval Capability and Quality Performance

The second proposed relationship examined the association between PPAP Approval Capability and organisational Quality Performance. Table 5 presents the empirical validation results.

Table 5
Empirical Validation of PPAP Approval Capability and Quality Performance

PPAP Approval Capability Item	**Quality Performance Item**	**Spearman's ρ**	**Significance**	**Framework Decision**
PA2 – Documented management control system exists	QP8 – Standard reaction plans defined for processes that are not capable	**0.630**	$p < 0.01$	**Retained**
PA3 – Supplier PPAP documentation is reviewed and incorporated	QP8 – Standard reaction plans defined for processes that are not capable	**0.621**	$p < 0.01$	**Retained**

Framework Validation Criterion: Spearman's $\rho \geq 0.60$ ($p < 0.01$)

Together, these findings indicate that PPAP Approval Capability supports Quality Performance through both management control and supplier information integration. This is consistent with the preventive orientation of PPAP, which emphasises the identification and management of process risks before they result in customer quality problems (Belu et al., 2013; Kumar Singh & Modgil, 2023). Both relationships were therefore retained in the Evidence-Based PPAP Approval Capability Framework.

PPAP Approval Capability and Overall Equipment Effectiveness

The third proposed relationship examined the association between PPAP Approval Capability and Overall Equipment Effectiveness (OEE). Table 6 presents the empirical validation results.

Table 6
Empirical Validation of PPAP Approval Capability and Overall Equipment Effectiveness

PPAP Approval Capability Item	OEE Item	Spearman's ρ	Significance	Framework Decision
No organisational relationship satisfied the predefined framework validation criterion (ρ ≥ 0.60)	-	< 0.60	-	Not Retained

Framework Validation Criterion: Spearman's ρ ≥ 0.60 (p < 0.01)

None of the tested organisational relationships met the predefined framework validation criterion of Spearman's ρ ≥ 0.60 and p < 0.01. Even if there were some positive correlations found, their correlation coefficients were still below the necessary cutoff. As a result, the modified framework's PPAP Approval Capability–OEE link could not be supported by the empirical data.

This result is in line with the two structures' distinct operational focuses. While OEE is more directly impacted by equipment availability, performance, maintenance, machine dependability, and production scheduling, PPAP mainly deals with product and process approval, quality assurance, and manufacturing capabilities (Rahman et al., 2022; Fuad et al., 2025). As a result, the relationship between PPAP and OEE may be indirect and reliant on other operational skills.

As a result, the Evidence-Based PPAP Approval Capability Framework did not include the suggested PPAP Approval Capability–OEE link.

Summary of Framework Validation
The validation decisions are summarised in **Table 7**, which shows that two of the three proposed organisational relationships met the predefined validation criterion and were retained in the final framework.

Table 7
Summary of Framework Validation

Proposed Organisational Relationship	Empirical Support	Framework Decision
PPAP Approval Capability → Supplier Quality Performance	Supported	Retained
PPAP Approval Capability → Quality Performance	Supported	Retained
PPAP Approval Capability → Overall Equipment Effectiveness	Not Supported	Not Retained

The Supplier Quality Performance pathway was supported by PA3 → QPS1 (ρ = 0.742, p < 0.01). The Quality Performance pathway was supported by PA2 → QP8 (ρ = 0.630, p < 0.01) and PA3 → QP8 (ρ = 0.621, p < 0.01). In contrast, the proposed PPAP Approval Capability → OEE relationship did not meet the validation criterion and was excluded.

These findings demonstrate that empirical validation can refine the preliminary framework by retaining relationships with sufficient evidence and excluding those that do not meet the predefined criterion.

Development of The Evidence-Based PPAP Approval Capability Framework

Framework Refinement

The preliminary PPAP Approval Capability Framework was refined based on the correlation results between individual PPAP Approval (PA) variables and the selected performance indicators. Using the predefined criterion of $\rho \geq 0.600$ and $p < 0.01$, three relationships were identified as sufficiently supported for inclusion in the final framework.

The strongest relationship was between PA3, representing supplier PPAP documentation integration, and QPS1, representing supplier quality data capture ($\rho = 0.742$, $p < 0.01$). Two additional relationships involved Quality Performance: PA2, representing the existence of a documented management control system, and QP8, representing standard reaction plans for processes that are not capable ($\rho = 0.630$, $p < 0.01$), and PA3 and QP8 ($\rho = 0.621$, $p < 0.01$).

No PPAP Approval–OEE relationship met the predefined validation criterion. Accordingly, the final framework retains only the empirically supported relationships identified through the correlation analysis, with particular emphasis on supplier documentation integration and management control as the PPAP practices associated with quality-related outcomes.

Evidence-Based PPAP Approval Capability Framework

The final Evidence-Based PPAP Approval Capability Framework is presented in Figure 3. Figure 3 illustrates the validated relationships identified from the correlation analysis of the PA independent variables with Supplier Quality Performance and Quality Performance.

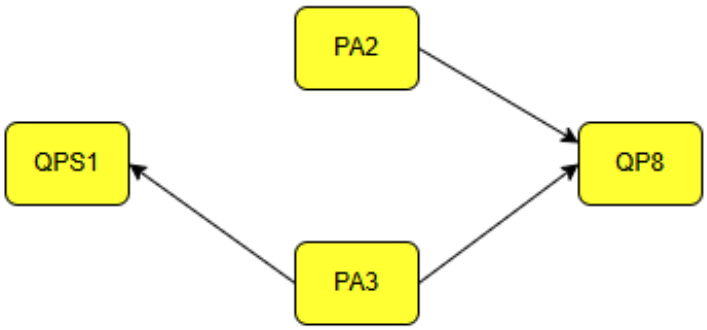

Figure 3 Evidence-Based PPAP Approval Capability Framework

The framework identifies three validated relationships. The strongest relationship connects supplier PPAP documentation integration (PA3) with supplier quality data capture (QPS1) ($\rho = 0.742$, $p < 0.01$). PA3 also demonstrates a positive relationship with standard reaction plans for processes that are not capable (QP8) ($\rho = 0.621$, $p < 0.01$). In addition, the existence of a documented management control system (PA2) is positively associated with QP8 ($\rho = 0.630$, $p < 0.01$).

These relationships indicate that the PPAP practices most strongly associated with quality-related outcomes are supplier documentation integration and documented management control. The final framework therefore focuses on the specific PA variables that demonstrated sufficient empirical support rather than assuming that all PPAP practices contribute equally to supplier performance.

No PA relationship with OEE met the predefined validation criterion. The framework consequently does not establish a direct PPAP–OEE relationship and remains focused on the quality-related relationships supported by the empirical evidence.

Discussion

PPAP Documentation Integration and Supplier Quality Performance

The strongest empirical relationship was between supplier PPAP documentation integration (PA3) and supplier quality data capture (QPS1), with $\rho = 0.742$ ($p < 0.01$). This finding indicates that systematic review and integration of supplier PPAP documentation are strongly associated with the availability of supplier quality information for each Bill of Materials (BOM) item.

The result highlights the information-management role of PPAP. When supplier technical and quality documentation is systematically integrated, it can provide a structured basis for assessing supplier capability, quality status, and compliance with requirements. This supports the collaborative and preventive orientation of PPAP within automotive supply chains (Mohamad et al., 2015; Belu et al., 2013; Kumar Singh & Modgil, 2023).

PPAP Management Control, Documentation Integration and Quality Performance

Two validated relationships were identified with QP8, representing standard reaction plans for processes that are not capable. Documented management control systems (PA2) were associated with QP8 at $\rho = 0.630$ ($p < 0.01$), while supplier PPAP documentation integration (PA3) was associated with QP8 at $\rho = 0.621$ ($p < 0.01$).

Together, these findings indicate that PPAP-related quality practices operate through both organisational control and information integration. Management controls provide a structured basis for responding to process capability problems, while supplier documentation provides information to support quality decisions. Thus, PPAP extends beyond customer approval and can form part of broader quality management practices (Belu et al., 2013; Kumar Singh & Modgil, 2023).

Non-Validated Relationship with Overall Equipment Effectiveness

No PPAP Approval relationship with OEE met the predefined criterion of $\rho \geq 0.60$ and $p < 0.01$. This result defines an important boundary of the framework. OEE is influenced by equipment availability, reliability, maintenance, production scheduling, and operational practices, whereas PPAP primarily addresses product and process approval, quality assurance, and manufacturing capability (Rahman et al., 2022; Fuad et al., 2025).

The finding therefore does not indicate that PPAP is unrelated to equipment performance; rather, the evidence was insufficient to establish a direct PA–OEE relationship under the study's validation criterion.

Contributions and Managerial Implications

The study contributes an evidence-based approach to PPAP capability framework development by using predefined correlation criteria to identify specific PPAP practices associated with quality-related outcomes. The resulting framework identifies supplier documentation integration (PA3) and documented management control (PA2) as the practices most clearly associated with the selected quality indicators.

For automotive suppliers, the findings suggest that PPAP documentation should be managed as an organisational quality resource rather than merely as a customer submission. Suppliers should systematically integrate documentation, establish documented management controls, and define standard reaction plans for processes that are not capable. At the same time, PPAP should be complemented by maintenance, reliability, production planning, and other operational practices when equipment effectiveness is the objective.

Methodologically, the study demonstrates how correlation results can be translated into a practical capability framework rather than retaining all relationships proposed in the preliminary model. This provides a basis for applying the same approach to other organisational capabilities within the broader Supplier Competitiveness Level framework.

Limitations and Future Research

This study has several limitations. First, the analysis was based on 88 responses from Malaysian automotive manufacturing organizations, which limits its applicability beyond this geographical and industrial context; future research should test the framework across other countries and manufacturing sectors. Second, associations rather than causal linkages are found using the cross-sectional design and Spearman's correlation; these could be further investigated by longitudinal study and structural equation modeling (SEM). Third, future research could expand the framework to include additional aspects of supplier competitiveness, such as delivery, cost, responsiveness, customer happiness, and new product introduction performance. The study concentrated on Supplier Quality Performance, Quality Performance, and OEE. Lastly, the framework is one capability-specific part of the larger Supplier Competitiveness Level framework, offering a chance to create a more thorough supplier competitiveness model by applying the same evidence-based methodology to additional organizational capabilities.

Conclusion

Through literature review, empirical validation, and framework improvement, this project created an Evidence-Based PPAP Approval Capability Framework for Malaysian automakers. Three relationships—PA3 → QPS1 ($\rho = 0.742$), PA2 → QP8 ($\rho = 0.630$), and PA3 → QP8 ($\rho = 0.621$)—met the predetermined criteria of $\rho > 0.60$ and $p < 0.01$ based on 88 responses. The requirement was not met by any PA–OEE relationship. The results define the validated boundary between PPAP and equipment effectiveness and highlight supplier PPAP documentation integration and management control as critical practices linked to quality outcomes.

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Conflict of Interest
There was no relevant conflict of interest regarding this paper.

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