

# Developing an Evidence-Based Capability Framework for Supplier Competitiveness: Application to Lean Manufacturing Capability in Malaysian Automotive Manufacturing

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DOI: <https://doi.org/10.47772/IJRISS.2026.100801060>

Received: 01 September 2026; Accepted: 15 September 2026; Published: 24 September 2026

## ABSTRACT

Lean Manufacturing has long been recognised as an important organisational capability for improving manufacturing performance and enhancing supplier competitiveness. However, existing studies have predominantly examined statistical relationships between Lean Manufacturing practices and operational performance, with limited attention to translating empirical evidence into practical organisational capability frameworks. This study addresses this gap by developing an Evidence-Based Lean Manufacturing Capability Framework through a systematic framework development methodology. A preliminary framework was established through a comprehensive review of the Lean Manufacturing and supplier competitiveness literature and subsequently evaluated using data collected from 88 Malaysian automotive manufacturing organisations. Reliability assessment and Spearman's rank-order correlation analysis were employed to evaluate the empirical associations underlying the proposed organisational relationships and guide framework refinement. The results identified significant positive associations between LM11 and the Supplier Quality Performance measure ( $\rho = 0.704$ ,  $p < 0.001$ ), LM11 and the Delivery Performance measure ( $\rho = 0.713$ ,  $p < 0.001$ ), and LM7 and the Delivery Performance measure ( $\rho = 0.639$ ,  $p < 0.001$ ). In contrast, the proposed relationship between Lean Manufacturing Capability and Quality Performance did not satisfy the predefined validation criterion and was excluded from the final framework. The validated relationships were subsequently synthesised into an Evidence-Based Lean Manufacturing Capability Framework, providing a structured representation of how Lean Manufacturing Capability relates to supplier competitiveness. The study contributes by demonstrating a transparent methodology for transforming a preliminary conceptual framework into an empirically validated organisational capability framework. Beyond validating organisational relationships, the methodology provides manufacturing organisations with a practical approach for developing evidence-based capability frameworks to support continuous improvement and supplier competitiveness.

**Keywords:** Lean Manufacturing Capability; Supplier Competitiveness; Organisational Capability; Evidence-Based Framework; Framework Development; Automotive Manufacturing; Malaysia

## INTRODUCTION

Supplier competitiveness has become increasingly important within the global automotive manufacturing industry as manufacturers seek to satisfy stringent customer requirements while maintaining operational efficiency, product quality, delivery reliability, and long-term business sustainability. The growing complexity of automotive supply chains, together with rapid technological advancement and intensifying global competition, requires suppliers to continuously strengthen their organisational capabilities to remain competitive. Consequently, competitiveness is no longer determined solely by production capacity or cost efficiency but

increasingly depends on the effective development and integration of organisational capabilities that support continuous operational improvement and superior manufacturing performance (Harifi, 2024; Ivanov & Dolgui, 2021; Chervenкова & Ivanov, 2023).

Among the organisational capabilities supporting supplier competitiveness, Lean Manufacturing Capability has received considerable attention because of its ability to improve manufacturing efficiency through systematic waste elimination, continuous improvement, process standardisation, and effective resource utilisation. Previous studies have consistently reported that lean implementation contributes to improvements in operational performance, manufacturing flexibility, product quality, and customer responsiveness (Tortorella et al., 2019; Moyano-Fuentes et al., 2021; Buer et al., 2020; Chiarini & Kumar, 2021). Despite this growing body of knowledge, existing research has predominantly focused on examining the relationship between Lean Manufacturing practices and organisational performance, with comparatively limited attention devoted to translating empirical findings into structured organisational capability frameworks that can support practical implementation within manufacturing organisations.

This limitation is particularly important because statistically significant organisational relationships do not automatically provide practitioners with practical guidance for capability development. Although empirical studies frequently demonstrate that Lean Manufacturing improves organisational performance, comparatively few studies explain how validated evidence can be systematically integrated into an evidence-based organisational capability framework suitable for industrial implementation. Consequently, manufacturing organisations often possess empirical evidence regarding the effectiveness of Lean Manufacturing without a structured methodology for translating that evidence into an operational framework capable of supporting continuous organisational improvement.

To address this limitation, the present study adopts a framework development perspective by demonstrating how a preliminary Lean Manufacturing Capability Framework can be systematically refined into an Evidence-Based Lean Manufacturing Capability Framework through empirical validation. Rather than treating statistical analysis as the final outcome of the research, the validated organisational relationships are used as objective decision criteria for refining the preliminary conceptual framework into an operational capability framework that supports supplier competitiveness within Malaysian automotive manufacturing organisations.

The proposed methodology consists of four stages: (i) preliminary framework development through literature synthesis and industrial knowledge, (ii) empirical validation using data from Malaysian automotive manufacturing organisations, (iii) framework refinement based on supported relationships, and (iv) development of the evidence-based framework. The overall research context and position of Lean Manufacturing Capability within the Supplier Competitiveness Framework are illustrated in Figure 1.

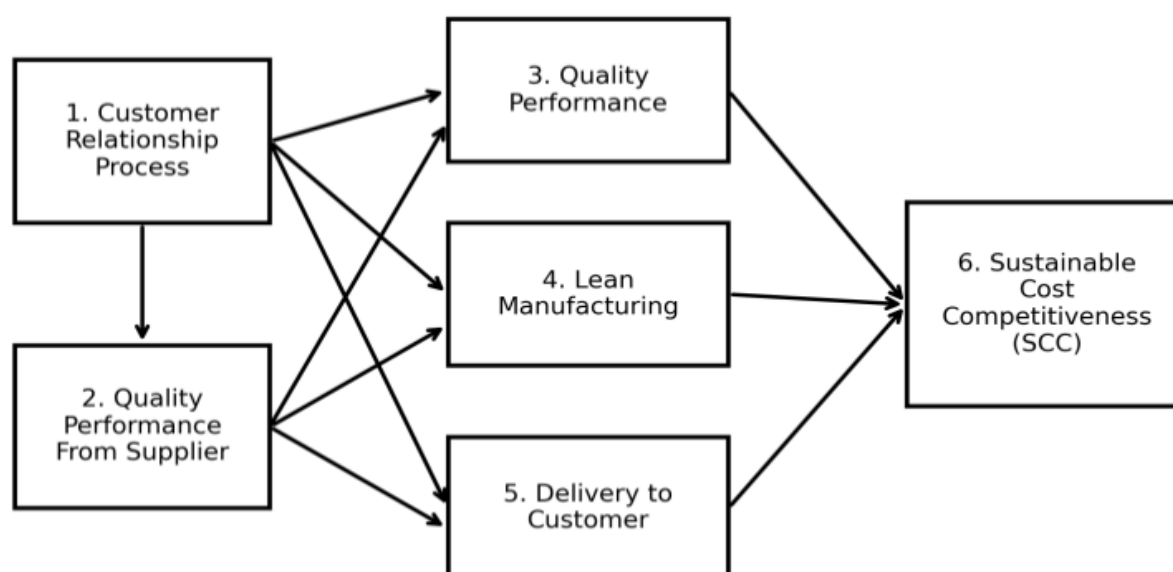


**Figure 1 Overall Supplier Competitiveness Level (SCL) Framework**

## LITERATURE REVIEW

### Supplier Competitiveness

Supplier competitiveness has become a strategic priority within the automotive manufacturing industry as manufacturers face increasing pressure to deliver high-quality products, maintain reliable delivery performance, improve operational efficiency, and respond rapidly to changing customer requirements. The growing complexity of global supply chains, together with intensified market competition and technological advancement, has shifted the emphasis from traditional production efficiency towards the development of organisational capabilities that support sustainable competitive advantage (Harifi, 2024; Ivanov & Dolgui, 2021; Chervenkova & Ivanov, 2023).

Contemporary research recognises supplier competitiveness as a multidimensional organisational outcome influenced by the integration of strategic and operational capabilities. While traditional competitive priorities such as cost, quality, and delivery remain important, suppliers are increasingly expected to demonstrate organisational capabilities that facilitate continuous improvement, manufacturing flexibility, innovation, and collaborative supply chain relationships. These capabilities enable organisations to enhance operational resilience and sustain long-term competitiveness within increasingly dynamic manufacturing environments (Porter, 1985; Banga, 2019; Foerstl et al., 2015; Abdul Kadir & Ali, 2011; Ariffin et al., 2020).

Existing studies further suggest that supplier competitiveness is not determined by a single organisational capability but rather by the collective contribution of multiple complementary capabilities that improve manufacturing performance and organisational effectiveness. Consequently, developing capability-specific frameworks has become increasingly important for understanding how individual organisational capabilities contribute to overall supplier competitiveness and how these relationships may be translated into practical organisational improvement strategies.

As introduced in Figure 1, the present research conceptualises supplier competitiveness as the outcome of multiple organisational capabilities operating within an integrated Supplier Competitiveness Framework. The present paper focuses specifically on Lean Manufacturing Capability and examines the association between this capability and supplier competitiveness through a systematic framework development methodology. The following section therefore reviews the literature relating to Lean Manufacturing Capability and establishes the theoretical foundation for developing the preliminary framework that is subsequently subjected to empirical validation.

### Lean Manufacturing Capability

Lean Manufacturing has evolved from a production improvement philosophy into a strategic organisational capability that enables manufacturing organisations to systematically improve operational performance through the elimination of waste, continuous improvement, and effective resource utilisation. Initially developed to enhance production efficiency, Lean Manufacturing is now recognised as an integrated management approach encompassing organisational culture, leadership commitment, employee involvement, and process optimisation. Consequently, organisations that successfully institutionalise Lean Manufacturing are better positioned to improve manufacturing efficiency while sustaining long-term operational excellence (Tortorella et al., 2019; Moyano-Fuentes et al., 2021).

The theoretical foundations of Lean Manufacturing can be traced to the Toyota Production System and its subsequent development into the broader concept of lean production. Womack, Jones, and Roos (2007) provided an influential account of lean production through their examination of the Toyota Production System and its development in the automotive industry. Womack and Jones (2003) subsequently articulated Lean Thinking around value, value streams, flow, pull, and the pursuit of perfection. The underlying principles of the Toyota Production System further emphasise standardised processes, clearly specified work, and systematic problem solving as important characteristics of lean production systems (Spear & Bowen, 1999). From an empirical measurement perspective, lean manufacturing practices have been examined as interconnected practice bundles

(Shah & Ward, 2003), while Shah and Ward (2007) further developed a multidimensional approach for defining and measuring lean production practices. These foundational works provide theoretical and measurement support for treating Lean Manufacturing Capability as an integrated organisational capability rather than as a collection of isolated manufacturing techniques.

Rather than representing a collection of isolated manufacturing tools, Lean Manufacturing Capability reflects an organisation's ability to integrate lean principles throughout its operational and managerial practices. Previous studies consistently demonstrate that effective lean implementation requires the systematic coordination of continuous improvement initiatives, process standardisation, employee engagement, and organisational learning. These interrelated practices enable organisations to reduce process variability, improve production flexibility, enhance manufacturing consistency, and establish a culture of continuous improvement capable of supporting sustainable organisational performance (Tortorella et al., 2019; Buer et al., 2020). Evidence from Malaysian manufacturing further highlights the importance of documented workflows, process

control, employee involvement, and integrated maintenance in supporting process consistency, quality, waste reduction, and manufacturing competitiveness (Wan Mahmood et al., 2026).

Within the automotive manufacturing industry, Lean Manufacturing Capability has become increasingly important as manufacturers seek to improve productivity while maintaining stringent quality and delivery requirements. Beyond improving production efficiency, lean implementation contributes to greater operational responsiveness, improved workflow integration, and more effective utilisation of organisational resources. These improvements enable manufacturing organisations to respond more effectively to changing customer expectations and increasingly competitive market environments (Moyano-Fuentes et al., 2021; Chiarini & Kumar, 2021).

Collectively, the literature indicates that Lean Manufacturing should be viewed as a strategic organisational capability rather than solely as a manufacturing philosophy or a collection of operational techniques. This capability perspective provides the theoretical foundation adopted in the present study, whereby Lean Manufacturing Capability is conceptualised as the organisational capability to systematically eliminate waste, optimise manufacturing processes, and continuously improve operational performance through integrated organisational practices. This operational definition provides the basis for examining the association between Lean Manufacturing Capability and supplier competitiveness in the subsequent section.

### **Lean Manufacturing Capability and Supplier Competitiveness**

The relationship between Lean Manufacturing Capability and supplier competitiveness has received considerable attention in manufacturing and operations management research. Previous studies consistently suggest that organisations possessing stronger Lean Manufacturing Capability are better able to improve operational performance by eliminating waste, optimising production processes, enhancing manufacturing flexibility, and supporting continuous improvement initiatives. These operational improvements enable manufacturing organisations to respond more effectively to customer requirements while strengthening their competitive position within increasingly dynamic automotive supply chains (Tortorella et al., 2019; Moyano-Fuentes et al., 2021).

From an organisational capability perspective, Lean Manufacturing contributes to supplier competitiveness by improving the consistency and reliability of manufacturing operations. Effective implementation of lean practices reduces process variability, enhances workflow integration, shortens production lead times, and improves resource utilisation, thereby enabling organisations to achieve higher levels of manufacturing efficiency and operational responsiveness. Collectively, these improvements strengthen an organisation's ability to satisfy customer expectations relating to quality, delivery, and overall operational performance (Buer et al., 2020; Chiarini & Kumar, 2021).

Although previous studies provide substantial empirical evidence supporting the positive association between Lean Manufacturing and manufacturing performance, the majority of existing research has concentrated on testing individual relationships between lean practices and specific operational outcomes. Consequently,

empirical findings are frequently presented as independent statistical relationships without demonstrating how the validated evidence may be systematically integrated into an organisational capability framework that supports managerial decision-making and capability development. This limitation reduces the practical applicability of existing research, particularly for manufacturing organisations seeking structured guidance for implementing Lean Manufacturing Capability to enhance supplier competitiveness.

Accordingly, the present study adopts a framework development perspective by viewing empirically validated organisational relationships as the foundation for developing an evidence-based organisational capability framework. Rather than treating statistical significance as the final outcome of the research, the validated relationships are systematically synthesised to refine a preliminary conceptual framework into an operational framework capable of supporting organisational capability development. This approach extends existing Lean Manufacturing research beyond relationship validation by demonstrating how empirical evidence can be translated into a practical framework for improving supplier competitiveness within Malaysian automotive manufacturing organisations.

The literature synthesis presented in this section therefore provides the theoretical justification for developing the preliminary Lean Manufacturing Capability Framework. The following section integrates the literature with industrial knowledge to establish the preliminary conceptual framework that is subsequently subjected to empirical validation.

### Development of the Preliminary Lean Manufacturing Capability Framework

Building upon the literature synthesis presented in Sections 2.1–2.3, a preliminary Lean Manufacturing Capability Framework was developed to guide the empirical investigation undertaken in this study. Rather than representing the final outcome of the research, the framework serves as a conceptual model that captures the organisational relationships proposed through existing literature prior to empirical validation. It provides the theoretical foundation for examining the association between Lean Manufacturing Capability and supplier competitiveness within Malaysian automotive manufacturing organisations.

The preliminary framework was developed based on the premise that Lean Manufacturing Capability functions as a strategic organisational capability that may be associated with supplier competitiveness through improvements in key operational performance dimensions. Drawing upon the literature reviewed in the preceding sections, the framework proposes that organisations possessing stronger Lean Manufacturing Capability are expected to achieve superior Quality Performance, Delivery Performance, and Supplier Quality Performance. These proposed relationships are derived from theoretical and empirical evidence reported in previous studies and therefore require empirical validation before they can be incorporated into an evidence-based organisational capability framework.

The preliminary Lean Manufacturing Capability Framework developed for this study is presented in Figure 2.

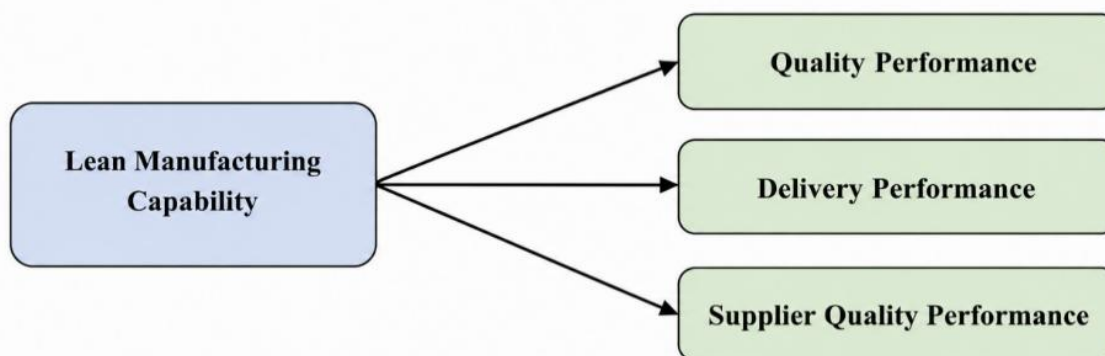


**Figure 2 Preliminary Lean Manufacturing Capability Framework**

As illustrated in Figure 2, Lean Manufacturing Capability is conceptualised as the independent organisational capability under examination in relation to three dimensions of supplier performance. Quality Performance represents the organisation's ability to consistently satisfy product quality requirements, Delivery Performance reflects the capability to fulfil customer delivery expectations reliably, while Supplier Quality Performance captures the supplier's effectiveness in maintaining quality standards throughout manufacturing operations. Collectively, these dimensions represent the principal organisational outcomes through which Lean Manufacturing Capability is expected to be associated with supplier competitiveness.

It is important to emphasise that Figure 2 represents a preliminary conceptual framework developed from the literature rather than an empirically validated model. The framework therefore does not assume that all proposed organisational relationships will be supported during statistical analysis. Instead, each relationship will be systematically evaluated using empirical evidence obtained from Malaysian automotive manufacturing organisations. Only relationships receiving empirical support will be retained during the framework refinement process, leading to the development of the Evidence-Based Lean Manufacturing Capability Framework presented in Section 5.

Unlike conventional empirical studies that conclude the literature review with a set of research hypotheses, the present study concludes with a preliminary organisational capability framework that serves as the starting point for the proposed framework development methodology. The following section describes the research methodology adopted to empirically validate the proposed organisational relationships and refine the preliminary framework into an evidence-based organisational capability framework.

## Research Design

The present study adopted a quantitative research design to develop and empirically validate an Evidence-Based Lean Manufacturing Capability Framework for Malaysian automotive manufacturing organisations. The research was conducted using a framework development methodology in which a preliminary conceptual framework, derived from the literature, was systematically evaluated and refined using empirical evidence. This approach enabled the proposed organisational relationships to be objectively assessed before being incorporated into the final capability framework.

Unlike conventional empirical studies that primarily seek to test hypotheses or explain causal relationships, the present research emphasises framework development. Statistical analysis therefore served as a mechanism for evaluating the organisational relationships proposed within the preliminary Lean Manufacturing Capability Framework rather than representing the final outcome of the study. Relationships receiving empirical support were retained during framework refinement, while unsupported relationships were excluded from the final framework. Consequently, the resulting framework represents an integration of theoretical understanding and empirical evidence, providing a practical organisational capability framework for improving supplier competitiveness.

The research design comprised four sequential stages. First, a preliminary Lean Manufacturing Capability Framework was developed through a synthesis of the relevant literature. Second, a structured questionnaire was designed to measure the organisational capability constructs represented within the preliminary framework. Third, quantitative data were collected from Malaysian automotive manufacturing organisations and analysed to evaluate the proposed organisational relationships. Finally, the empirical findings were used to refine the preliminary framework into an Evidence-Based Lean Manufacturing Capability Framework.

The overall framework development procedure adopted in this study is illustrated in Figure 3. The figure summarises the systematic process through which theoretical knowledge was translated into an evidence-based organisational capability framework.

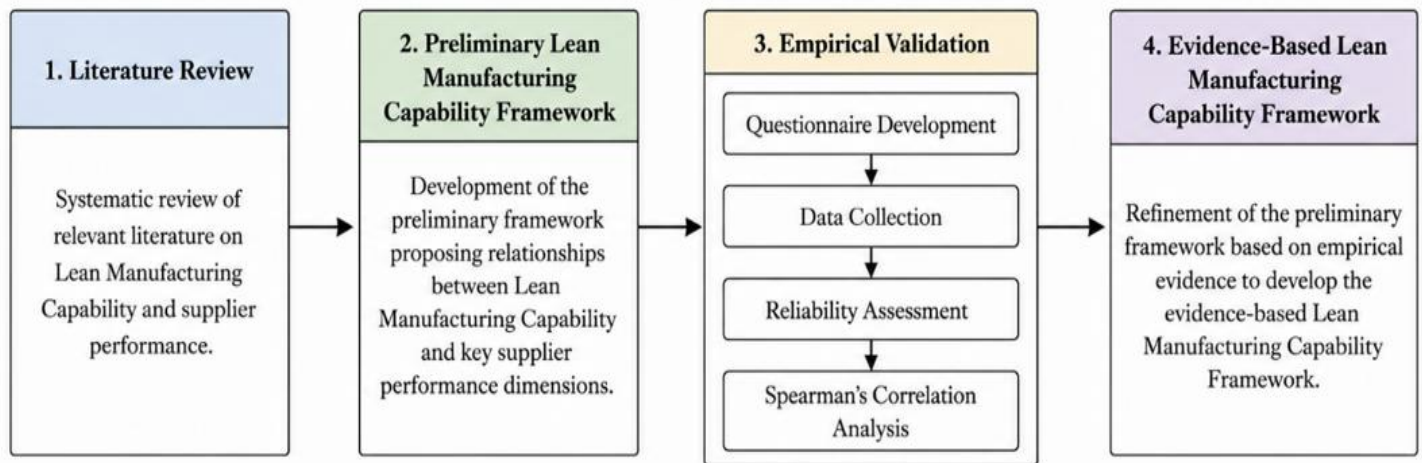


**Figure 3 Framework Development Procedure**

As illustrated in Figure 3, the proposed methodology provides a transparent and systematic approach for transforming a preliminary conceptual framework into an evidence-based organisational capability framework. Rather than relying solely on theoretical propositions, the framework development process incorporates empirical validation as the principal decision criterion for retaining organisational relationships within the final framework. This methodology therefore provides a structured approach that may be adapted for developing additional organisational capability frameworks supporting supplier competitiveness within manufacturing organisations.

### Framework Development Procedure

The framework development procedure adopted in this study consisted of four sequential stages designed to systematically transform theoretical knowledge into an evidence-based organisational capability framework. Rather than relying solely on conceptual reasoning, the proposed methodology incorporated empirical validation to determine which organisational relationships should be retained during framework refinement. This approach ensured that the final framework was supported by both theoretical justification and empirical evidence.

The first stage involved the development of a preliminary Lean Manufacturing Capability Framework through a comprehensive review and synthesis of the relevant literature. The literature review established the theoretical relationships between Lean Manufacturing Capability and the selected supplier performance dimensions, providing the conceptual foundation for the preliminary framework presented in Section 2.

The second stage focused on the development of a structured measurement instrument capable of evaluating the proposed organisational relationships. Questionnaire items representing Lean Manufacturing Capability and the corresponding supplier performance dimensions were adopted and adapted from established literature and contextualised to reflect the operational characteristics of Malaysian automotive manufacturing organisations. The questionnaire was designed to obtain the empirical evidence required for subsequent framework validation.

The third stage comprised empirical validation of the preliminary framework using quantitative data collected from Malaysian automotive manufacturing organisations. The measurement instrument was first assessed for internal consistency through reliability analysis before Spearman's correlation analysis was performed to evaluate the proposed organisational relationships. Rather than serving as an end in itself, the statistical analysis provided the objective evidence required to determine whether each proposed relationship should be retained during framework refinement.

The final stage involved the development of the Evidence-Based Lean Manufacturing Capability Framework. Organisational relationships receiving empirical support were retained and incorporated into the refined framework, while unsupported relationships were excluded. The resulting framework therefore represents an integration of theoretical understanding and empirical evidence, providing a practical organisational capability

framework for improving supplier competitiveness within Malaysian automotive manufacturing organisations.

This systematic framework development procedure provides a transparent and repeatable methodology for transforming a preliminary conceptual framework into an evidence-based organisational capability framework. Although demonstrated using Lean Manufacturing Capability, the same methodological approach may be applied to other organisational capabilities contributing to supplier competitiveness.

## Instrument Development

Following the development of the preliminary Lean Manufacturing Capability Framework, a structured questionnaire was developed to empirically evaluate the proposed organisational relationships. The measurement instrument was designed to capture the organisational capability represented by Lean Manufacturing Capability together with the supplier performance dimensions incorporated within the preliminary framework. The questionnaire provided the empirical evidence required to validate and subsequently refine the proposed organisational capability framework.

The measurement items were adopted and adapted from validated instruments reported in previous studies and were contextualised to reflect the operational characteristics of Malaysian automotive manufacturing organisations. The questionnaire consisted of two principal sections. The first section collected organisational demographic information, while the second comprised measurement items representing Lean Manufacturing Capability and the associated supplier performance dimensions included within the preliminary framework.

Responses were recorded using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), enabling respondents to evaluate the extent to which Lean Manufacturing practices and organisational performance characteristics were implemented within their organisations. The measurement constructs included in the questionnaire are summarised in Table 1.

**Table 1 Measurement Constructs and Questionnaire Structure**

| Construct                           | Number of Items                                               | Measurement Scale                                                     |
|-------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------|
| Lean Manufacturing Capability (LMC) | (Refer to Chapter 3 – Lean Manufacturing questionnaire items) | Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree) |
| Supplier Quality Performance (SQP)  | 3                                                             | Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree) |
| Quality Performance (QP)            | 9                                                             | Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree) |
| Delivery Performance (DP)           | 3                                                             | Five-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree) |

The target population comprised Malaysian automotive manufacturing organisations actively involved in automotive supply chain operations. Respondents included managers, engineers, executives, and practitioners responsible for manufacturing operations, production planning, quality management, continuous improvement, and Lean Manufacturing implementation. These respondents were selected because of their direct involvement in operational improvement initiatives and organisational capability development.

Prior to questionnaire distribution, the measurement instrument underwent content validation and clarity assessment to ensure that the questionnaire appropriately represented the organisational capability constructs included within the preliminary Lean Manufacturing Capability Framework. The objective of this stage was to establish a reliable measurement instrument capable of supporting the subsequent empirical validation and framework refinement process.

## Sampling and Data Collection

The empirical validation was conducted using data collected from Malaysian automotive manufacturing organisations operating within the national automotive supply chain. The target population comprised organisations actively engaged in automotive component manufacturing and supplier operations, representing a broad cross-section of firms contributing to the Malaysian automotive industry.

Respondents were purposively selected based on their involvement in organisational capability development and operational improvement activities. Accordingly, the questionnaire was administered to managers, engineers, executives, and practitioners responsible for manufacturing operations, Lean Manufacturing implementation, quality management, production planning, continuous improvement, and related operational functions. These respondents were considered well positioned to evaluate the implementation of Lean Manufacturing practices and their association with organisational performance.

Data were collected using a structured questionnaire distributed to participating organisations. Responses were obtained using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). A total of 88 valid responses were obtained and included in the empirical analysis. This sample provided the dataset required to evaluate the proposed organisational relationships and support the subsequent framework refinement process.

The organisational profile of the participating manufacturing firms is presented in Section 4.1, while the empirical validation results are reported in the subsequent sections. The collected data formed the basis for assessing the reliability of the measurement instrument and evaluating the proposed organisational relationships within the preliminary Lean Manufacturing Capability Framework.

## Data Analysis and Framework Validation

The empirical data were analysed using a systematic framework validation procedure designed to evaluate the organisational relationships proposed within the preliminary Lean Manufacturing Capability Framework. Rather than treating statistical analysis as the final outcome of the study, the analytical procedures were employed to determine whether the proposed organisational relationships should be retained during framework refinement.

The analysis commenced with an assessment of the internal consistency of the measurement constructs using Cronbach's alpha. Reliability assessment was undertaken to confirm that the questionnaire consistently measured the organisational capability constructs represented within the preliminary framework before empirical validation was performed. Establishing acceptable internal consistency ensured that the measurement instrument was suitable for evaluating the proposed organisational relationships.

Following confirmation of measurement reliability, Spearman's rank-order correlation analysis was employed to evaluate the strength and direction of the relationships between Lean Manufacturing Capability and the supplier performance dimensions. Spearman's correlation was selected because the study utilised ordinal data obtained from five-point Likert scale responses and sought to examine the association between organisational capability constructs without assuming a normal distribution of the data.

Spearman's rank-order correlation was used as an association-based validation procedure for framework refinement rather than as a structural modelling technique. Accordingly, the analysis does not establish causal relationships or evaluate indirect or mediation effects among the constructs. The purpose of the analysis was to identify relationships that satisfied the predefined empirical criterion and could therefore be retained in the evidence-based framework. Structural equation modelling may be considered in future research to provide further construct-level validation of the refined framework.

For framework refinement, an organisational relationship was considered empirically supported when the Spearman's correlation coefficient satisfied the predefined criterion of  $\rho \geq 0.60$  with  $p < 0.01$ . Relationships that did not satisfy this criterion were not retained in the refined framework.

The results of the correlation analysis were subsequently interpreted within the context of framework

development rather than conventional hypothesis testing. Organisational relationships demonstrating empirical support were retained and incorporated into the refined framework, whereas relationships that did not satisfy the predefined validation criterion were excluded. Consequently, empirical validation functioned as the principal decision mechanism for refining the preliminary conceptual framework into an evidence-based organisational capability framework.

This analytical approach provides a transparent and repeatable methodology for translating empirical evidence into framework development. The reliability assessment, empirical validation results, and framework refinement are presented in Section 4, while the resulting Evidence-Based Lean Manufacturing Capability Framework is presented in Section 5.

## EMPIRICAL VALIDATION RESULTS

### Respondent Profile

The empirical validation was conducted using responses obtained from 88 Malaysian automotive manufacturing organisations, representing a diverse cross-section of suppliers operating within the national automotive supply chain. The participating organisations varied in terms of production capacity utilisation, annual sales, workforce size, and export involvement, thereby providing a representative basis for evaluating the proposed organisational relationships within the preliminary Lean Manufacturing Capability Framework. The demographic characteristics of the participating organisations are summarised in Table 2.

**Table 2 Demographic Profile of Participating 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           |

As presented in Table 2, most participating organisations reported production capacity utilisation between 71% and 80% (31.8%), followed by 60–70% (22.7%) and 81–90% (22.7%), indicating that the majority operated within moderate to high production utilisation levels. This distribution suggests that the empirical validation incorporated organisations with established manufacturing operations while avoiding excessive operational

loading.

With respect to annual sales, 38.6% of the participating organisations reported annual sales exceeding RM100 million, while 36.4% recorded annual sales between RM10 million and RM50 million. These findings indicate that the respondent group was predominantly composed of medium- to large-scale manufacturing organisations with established positions within the Malaysian automotive supply chain.

The workforce profile further demonstrates the diversity of the participating organisations. Approximately 39.8% employed between 100 and 200 employees, whereas 26.1% employed more than 400 employees, reflecting substantial representation from both medium-sized and large manufacturing firms. In addition, 43.2% of the organisations were actively engaged in export activities, while 56.8% primarily served domestic markets. This balance enhances the relevance of the empirical findings by incorporating organisations operating across both local and international supply chains.

Overall, the respondent profile indicates that the empirical validation was conducted using organisations with diverse operational characteristics, organisational sizes, and market orientations. Such diversity strengthens the practical applicability of the Evidence-Based Lean Manufacturing Capability Framework across the Malaysian automotive manufacturing industry.

### Reliability Assessment

Prior to validating the proposed organisational relationships, the internal consistency of the measurement constructs was evaluated using Cronbach's alpha. Reliability assessment was undertaken to confirm that the questionnaire consistently measured the organisational capability constructs incorporated within the preliminary Lean Manufacturing Capability Framework before empirical validation was performed. Establishing acceptable internal consistency ensured that the measurement instrument was suitable for evaluating the proposed organisational relationships and supporting subsequent framework refinement.

The reliability assessment results are presented in Table 3.

**Table 3 Reliability Assessment of the Measurement Constructs**

| Construct                     | Code | Number of Items | Cronbach's Alpha | Interpretation                       |
|-------------------------------|------|-----------------|------------------|--------------------------------------|
| Lean Manufacturing Capability | LM   | 11              | 0.827            | Good reliability                     |
| Supplier Quality Performance  | QPS  | 3               | 0.528            | Acceptable for exploratory research* |
| Quality Performance           | QP   | 9               | 0.654            | Acceptable reliability               |
| Delivery Performance (DIFOT)  | DC   | 3               | 0.664            | Acceptable reliability               |

\*Cronbach's alpha values above 0.50 are considered acceptable for exploratory organisational research, particularly where constructs comprise a limited number of measurement items

As presented in Table 3, the measurement constructs demonstrated generally acceptable levels of internal consistency for the exploratory framework development. Lean Manufacturing Capability achieved the highest reliability coefficient ( $\alpha = 0.827$ ), indicating good internal consistency across the eleven measurement items. Delivery Performance ( $\alpha = 0.664$ ) and Quality Performance ( $\alpha = 0.654$ ) also demonstrated acceptable levels of reliability for exploratory organisational research. Supplier Quality Performance recorded a comparatively lower Cronbach's alpha coefficient ( $\alpha = 0.528$ ). This result should be interpreted with caution, particularly because the construct was represented by only three measurement items and may encompass multiple aspects of supplier quality management. Nevertheless, the construct was retained because it forms an integral component of the measurement instrument adopted from the thesis and represents an important dimension of supplier

competitiveness.

Overall, the reliability assessment provided a sufficient basis for proceeding with the empirical validation of the proposed organisational relationships. Consequently, all measurement constructs were retained for the Spearman's rank-order correlation analysis, which was undertaken to determine the organisational relationships to be incorporated into the Evidence-Based Lean Manufacturing Capability Framework.

### Validation of the Proposed Organisational Relationships

The preliminary Lean Manufacturing Capability Framework proposed in Figure 2 was empirically evaluated to determine whether the organisational relationships identified through the literature review were supported by evidence obtained from Malaysian automotive manufacturing organisations. Rather than treating statistical analysis as the primary outcome of the research, the empirical validation was undertaken to identify the organisational relationships that should be retained during framework refinement.

The proposed organisational relationships were evaluated using Spearman's rank-order correlation analysis. In accordance with the framework development methodology, only relationships satisfying the predefined validation criterion were retained for incorporation into the Evidence-Based Lean Manufacturing Capability Framework. The empirical validation results are presented in the following subsections.

### Validation of Lean Manufacturing Capability and Supplier Quality Performance

Supplier Quality Performance represents an important dimension of supplier competitiveness because it reflects an organisation's ability to maintain consistent supplier quality management practices throughout manufacturing operations. Accordingly, the relationship between Lean Manufacturing Capability and Supplier Quality Performance was evaluated to determine whether Lean Manufacturing practices contribute to strengthening supplier quality performance. The empirical validation results are presented in Table 4.

**Table 4 Validation of Lean Manufacturing Capability and Supplier Quality Performance**

| Lean Manufacturing Capability Item                                                             | Supplier Quality Performance Item | Spearman's $\rho$ | Significance | Framework Decision |
|------------------------------------------------------------------------------------------------|-----------------------------------|-------------------|--------------|--------------------|
| LM11 – Work instructions and inspection standards are clearly defined, visible, and up to date | QPS1                              | 0.704             | $p < 0.01$   | Retained           |

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

As presented in Table 4, one organisational relationship satisfied the predefined framework validation criterion. The strongest relationship was observed between LM11 and Supplier Quality Performance (QPS1) with a Spearman's correlation coefficient of 0.704 ( $p < 0.01$ ), indicating a strong positive association between standardised work instructions and supplier quality performance.

From a framework development perspective, the validated relationships indicate that Lean Manufacturing Capability is positively associated with delivery performance through the implementation of standardised work instructions, clearly defined inspection standards, and systematic quality review practices.

### Validation of Lean Manufacturing Capability and Quality Performance

Quality Performance represents an important dimension of supplier competitiveness because it reflects an organisation's ability to consistently achieve product quality requirements and minimise manufacturing defects. Accordingly, the relationship between Lean Manufacturing Capability and Quality Performance was evaluated to determine whether Lean Manufacturing practices contribute directly to improvements in organisational quality

performance. The empirical validation results are presented in Table 5.

**Table 5 Validation of Lean Manufacturing Capability and Quality Performance**

| Lean Manufacturing Capability Item                                                                           | Quality Performance Item | Highest Spearman's $\rho$ | Significance | Framework Decision |
|--------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------|--------------|--------------------|
| No organisational relationship satisfied the predefined framework validation criterion ( $\rho \geq 0.60$ ). | –                        | 0.577                     | $p < 0.01$   | Not Retained       |

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

As presented in Table 5, none of the organisational relationships between Lean Manufacturing Capability and Quality Performance satisfied the predefined framework validation criterion of  $\rho \geq 0.60$ . Although several statistically significant positive correlations were identified, their correlation coefficients remained below the threshold established for framework retention.

From a framework development perspective, these findings indicate that the empirical evidence was insufficient to support the direct inclusion of a Lean Manufacturing Capability–Quality Performance relationship within the refined framework. Consequently, this organisational relationship was not retained during framework refinement.

The findings also demonstrate the value of the proposed framework development methodology. Rather than retaining theoretical relationships solely because they are conceptually plausible, the methodology requires empirical evidence before a relationship is incorporated into the final capability framework. This evidence-based approach enhances the transparency, credibility, and practical applicability of the resulting organisational capability framework.

### Validation of Lean Manufacturing Capability and Delivery Performance

Delivery Performance represents a critical dimension of supplier competitiveness because it reflects an organisation's ability to consistently fulfil customer delivery requirements in terms of reliability and timeliness. Accordingly, the relationship between Lean Manufacturing Capability and Delivery Performance was evaluated to determine whether Lean Manufacturing practices contribute to improved delivery performance within Malaysian automotive manufacturing organisations. The empirical validation results are presented in Table 6.

**Table 6 Validation of Lean Manufacturing Capability and Delivery Performance**

| Lean Manufacturing Capability Item                                                             | Delivery Performance Item | Spearman's $\rho$ | Significance | Framework Decision |
|------------------------------------------------------------------------------------------------|---------------------------|-------------------|--------------|--------------------|
| LM11 – Work instructions and inspection standards are clearly defined, visible, and up to date | DC1                       | 0.713             | $p < 0.01$   | Retained           |
| LM7 – Regular quality reviews and continuous monitoring of manufacturing processes             | DC1                       | 0.639             | $p < 0.01$   | Retained           |

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

As presented in Table 6, two organisational relationships satisfied the predefined framework validation criterion. The strongest relationship was identified between LM11 and Delivery Performance (DC1) with a Spearman's correlation coefficient of 0.713 ( $p < 0.01$ ), followed by the relationship between LM7 and Delivery Performance

(DC1) ( $\rho = 0.639$ ,  $p < 0.01$ ). Both relationships demonstrated strong positive associations and therefore satisfied the criterion for framework retention.

From a framework development perspective, the validated relationships indicate that Lean Manufacturing Capability contributes to improved delivery performance through the implementation of standardised work instructions, clearly defined inspection standards, and systematic quality review practices. These organisational practices enhance process consistency, reduce operational variability, and support more reliable delivery performance within Malaysian automotive manufacturing organisations.

Consequently, both organisational relationships were retained during framework refinement and incorporated into the Evidence-Based Lean Manufacturing Capability Framework presented in Section 5

### Summary of Framework Validation

The empirical validation results presented in Sections 4.3.1–4.3.3 provide the evidence required to determine which organisational relationships should be retained within the proposed Lean Manufacturing Capability Framework. Rather than considering statistical significance alone, the framework refinement process adopted in this study utilised the predefined validation criterion to identify the organisational relationships supported by empirical evidence. The framework validation decisions are summarised in Table 7.

**Table 7 Summary of Framework Validation**

| Proposed Organisational Relationship                         | Empirical Support | Framework Decision |
|--------------------------------------------------------------|-------------------|--------------------|
| Lean Manufacturing Capability → Supplier Quality Performance | Supported         | Retained           |
| Lean Manufacturing Capability → Quality Performance          | Not Supported     | Not Retained       |
| Lean Manufacturing Capability → Delivery Performance         | Supported         | Retained           |

As summarised in Table 7, two of the three proposed organisational relationships received empirical support and were therefore retained during framework refinement. Specifically, the empirical evidence supported the proposed relationships with Supplier Quality Performance and Delivery Performance, whereas the proposed relationship with Quality Performance did not satisfy the predefined framework validation criterion and was therefore excluded from the refined framework.

These findings demonstrate the value of the proposed framework development methodology. Rather than retaining all theoretically proposed relationships, the methodology systematically incorporates only those organisational relationships supported by empirical evidence. Consequently, the resulting Evidence-Based Lean Manufacturing Capability Framework represents an integration of theoretical understanding and empirical validation, providing a more robust and practically relevant capability framework for improving supplier competitiveness within Malaysian automotive manufacturing organisations.

## DEVELOPMENT OF THE EVIDENCE-BASED LEAN MANUFACTURING CAPABILITY FRAMEWORK

This section presents the development of the Evidence-Based Lean Manufacturing Capability Framework, which integrates the theoretical relationships proposed in the preliminary framework with the empirical validation results presented in Section 4. Rather than reproducing the preliminary conceptual framework, the refined framework incorporates only the organisational relationships that satisfied the predefined empirical validation criterion. Consequently, the framework represents an integration of theoretical understanding and empirical evidence, providing a practical organisational capability framework for strengthening supplier competitiveness within Malaysian automotive manufacturing organisations.

## Framework Refinement Process

The preliminary Lean Manufacturing Capability Framework proposed three organisational relationships between Lean Manufacturing Capability and the supplier performance dimensions of Supplier Quality Performance, Quality Performance, and Delivery Performance. These relationships were systematically evaluated using Spearman's rank-order correlation analysis to determine whether they were supported by empirical evidence obtained from Malaysian automotive manufacturing organisations.

As summarised in Table 7, two of the three proposed organisational relationships satisfied the predefined framework validation criterion and were therefore retained during framework refinement. Specifically, the relationships between Lean Manufacturing Capability and Supplier Quality Performance, and between Lean Manufacturing Capability and Delivery Performance, demonstrated sufficient empirical support and were incorporated into the refined framework. In contrast, the proposed relationship between Lean Manufacturing Capability and Quality Performance did not satisfy the validation criterion and was consequently excluded from the final framework.

The framework refinement process demonstrates the value of the proposed methodology by ensuring that the final organisational capability framework is guided by empirical evidence rather than theoretical assumptions alone. By retaining only validated organisational relationships, the refined framework provides a more evidence-based representation of the associations between Lean Manufacturing Capability and supplier competitiveness within Malaysian automotive manufacturing organisations.

## Development of the Evidence-Based Lean Manufacturing Capability Framework

Figure 4 presents the Evidence-Based Lean Manufacturing Capability Framework developed through the proposed framework development methodology. Unlike the preliminary framework presented in Figure 2, the evidence-based framework retains only the organisational relationships that received empirical support during the validation process. The framework therefore illustrates the validated organizational associations between

Lean Manufacturing Capability and supplier competitiveness.

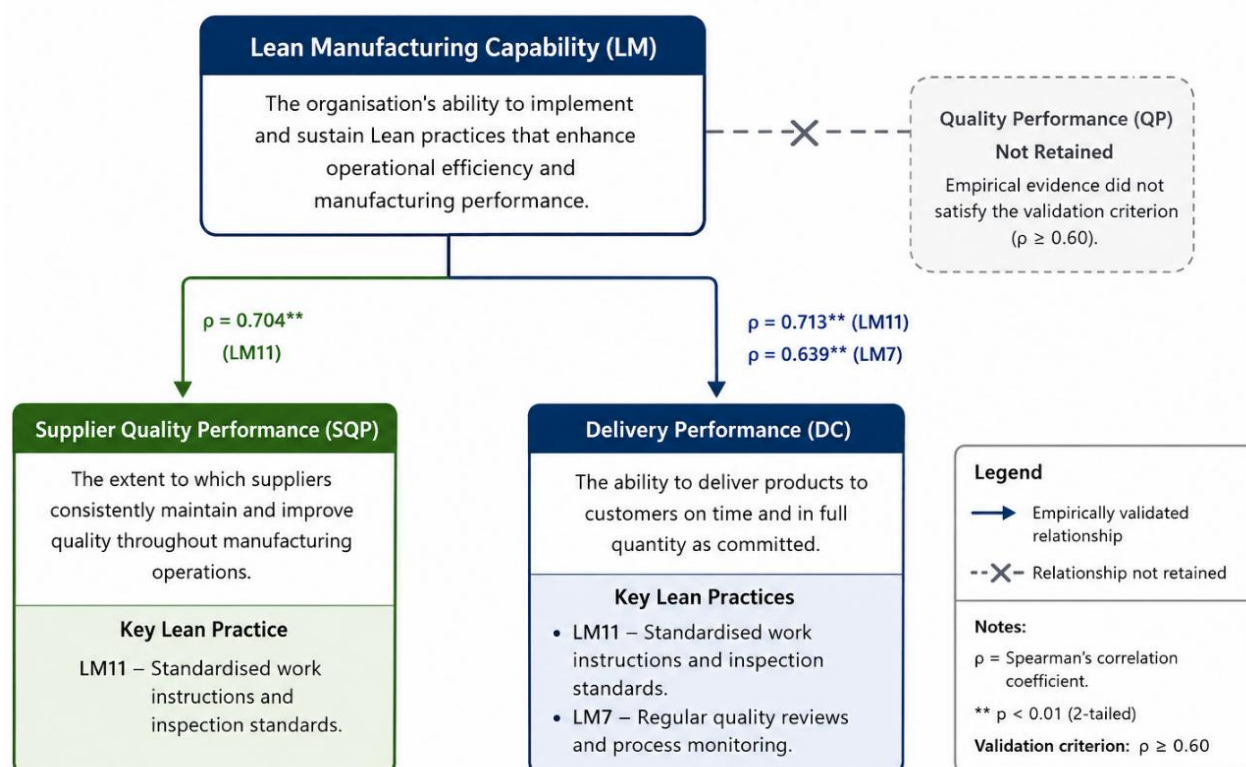


**Figure 4 Evidence-Based Lean Manufacturing Capability Framework**

The empirical validation indicates that Lean Manufacturing Capability is positively associated with Supplier Quality Performance and Delivery Performance through distinct organisational mechanisms. The relationship with Supplier Quality Performance was supported primarily through the implementation of standardised work instructions and inspection standards (LM11), highlighting the importance of process standardisation in strengthening supplier quality management. In contrast, Delivery Performance was supported through two complementary Lean Manufacturing practices: standardised work instructions and inspection standards (LM11) and regular quality reviews and process monitoring (LM7). Together, these practices are associated with process consistency, early identification of operational issues, and reliable product delivery.

Conversely, the empirical analysis did not provide sufficient evidence to retain a direct relationship between Lean Manufacturing Capability and Quality Performance. Although positive correlations were observed, none satisfied the predefined framework validation criterion. This finding suggests that improvements in organisational quality performance may depend on additional organisational capabilities beyond Lean Manufacturing alone, reinforcing the importance of validating conceptual relationships before incorporating them into practical capability frameworks.

Rather than presenting the individual statistical relationships as the principal outcome of the study, Figure 4 synthesises the validated organisational relationships into an operational capability framework that supports organisational decision-making and continuous improvement. The framework demonstrates how empirical evidence can be systematically translated into a practical management tool for strengthening supplier competitiveness within Malaysian automotive manufacturing organisations.

More broadly, the framework illustrates the proposed methodology for transforming a preliminary conceptual model into an evidence-based organisational capability framework. Although demonstrated using Lean Manufacturing Capability, the methodology provides a transparent and repeatable approach that may be adapted to develop and validate additional organisational capability frameworks contributing to supplier competitiveness.

## ACKNOWLEDGEMENTS

The researcher would like to acknowledge the Faculty of Industrial & Manufacturing Technology & Engineering, Universiti Teknikal Malaysia Melaka, Malaysia for the instruments and financial support.

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