School of Mechanical and Design Engineering

QMS Implementation in Engineering Organisations: A Comparative Study of Size-Contingent Practices and Outcomes in SMEs and Large Firms

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'I certify that this is my own work, and it has not previously been submitted for any assessed qualification. I certify that School of Engineering research ethics approval has been obtained and the use of material from other sources has been properly and fully acknowledged in the text'.

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Abstract

The comparative effectiveness of quality management system (QMS) implementation across organisations of differing scale remains underexplored in the ISO 9001 literature, despite the standard's widespread adoption across engineering organisations of varying size and operational complexity. This study comparatively evaluated QMS implementation effectiveness in SME and large engineering organisations across all five dimensions: Leadership and Strategic Commitment, Process Formalisation and Documented Control, Resource and Competence, Audit and Review Practices, and Continuous Improvement and Realised Impact. A structured questionnaire instrument was administered to 21 engineering professionals and analysed using a continuous five-dimension maturity scoring model, nonparametric inferential tests, and a Gauss Area Formula quantification of the resulting radar profile. Large organisations scored higher than SMEs across all five dimensions. The most conservative estimate of this gap, taken from the dimension ordering used in Figure 2 which returned the smallest difference of all twelve arrangements tested, was 57.7%. Accountability improvements showed the largest cross group divergence at 44.4 percentage points. Leadership commitment was comparable across both groups, indicating the implementation gap reflects capacity rather than intent. Documentation improvements were more frequently reported by SME respondents, confirming that size-contingent patterns are not uniformly directional. Process formalisation, audit frequency, and accountability improvement were identified as the most size-contingent dimensions, whilst leadership commitment represented the dimension least differentiated by organisational scale. These findings, whilst bounded by the cross-sectional design and modest sample scale, indicate that organisational size is associated with differential QMS implementation profiles across multiple dimensions, a conclusion that challenges undifferentiated approaches to ISO 9001 guidance and supports the case for size-contingent QMS frameworks in engineering practice.

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List of Abbreviations

Abbreviation	Definition
CAPA	Corrective and Preventive Action
EU	European Union
GDPR	General Data Protection Regulation
HQ	Headquarters
IMS	Integrated Management System
ISO	International Organisation for Standardisation
IQR	Inter Quartile Range
KPI	Key Performance Indicator
MES	Manufacturing Execution System
PDCA	Plan-Do-Check-Act
QMS	Quality Management System
RBT	Risk-Based Thinking
SME	Small and Medium Enterprise
UK	United Kingdom
WMW	Wilcoxon-Mann-Whitney

1.0 Introduction

1.1 Background Context

ISO 9001 is the dominant quality management system (QMS) standard globally, with 1,474,118 valid certificates across more than 170 countries as of 2024 (ISO/CASCO, 2025). Manufacturing and engineering related sectors account for a substantial share of these certificates, making them a significant adoption context where process control and documented governance have direct operational consequences. Adoption conditions vary widely however, from resource constrained SMEs with informal governance to large organisations with dedicated quality functions and extensive audit infrastructures (Bravi & Murmura, 2021). Despite this variation, ISO 9001 is applied uniformly, implicitly assuming that implementation mechanisms and their effectiveness are not systematically influenced by organisational size. Contingency theory challenges this assumption, identifying organisational size as a robust contextual variable in operations management and suggesting that uniform prescriptive approaches are unlikely to be equally effective across different organisational scales (Sousa & Voss, 2008; Taylor & Taylor, 2013). Whether these differences result in variations in QMS effectiveness across organisational dimensions remains underexplored; this study addresses that gap.

1.2 Research Problem and Rationale

Prior comparative studies provide descriptive evidence that organisational size influences QMS motivations, implementation practices, and perceived outcomes (Sun & Cheng, 2002; Bravi & Murmura, 2021). However, they do not translate these findings into structured, multi-dimensional evaluation frameworks for systematic cross organisational comparison. No established framework has been applied comparatively across SME and large engineering organisations to assess implementation effectiveness across multiple QMS governance dimensions simultaneously, a gap with direct implications for both size contingency theory and practitioner guidance. This study addresses the gap by operationalising a structured five-dimension evaluation framework. The framework incorporates a continuous maturity scoring model and quantified radar profile analysis, applied comparatively to provide grounded evidence for size-contingent QMS design.

1.3 Research Aim and Objectives

The aim of this dissertation is to comparatively evaluate QMS implementation effectiveness in SME and large engineering organisations across five defined dimensions and identify size-contingent implementation mechanisms and their consequences for improvement outcomes.

Four objectives are defined. First, compare the maturity profile of QMS implementation across SME and Large engineering organisations across five scoreable dimensions using a continuous scoring model and quantified radar profile analysis. Second, identify the mechanisms through which organisational size influences QMS implementation practice. Third, evaluate the relationship between formalisation depth and the profile of improvement outcomes. Fourth, derive implications for size-contingent QMS design and support in engineering organisations.

1.4 Terminological Definitions and Analytical Scope

The QMS literature utilises overlapping and inconsistently applied terminology, particularly across organisations of differing size. To ensure comparability, key terms are operationally defined in Table 1. The term "engineering organisation" is used throughout in preference to "firm", except where alignment with cited literature requires otherwise. ISO 9001 refers to ISO 9001:2015 unless an alternative revision is explicitly identified.

Table 1: Operational definitions of key terms applied in this dissertation

Term	Operational Definition	Reference
SME	An engineering organisation employing fewer than 250 employees with turnover not exceeding €50 million	(European Commission, 2003)
Large engineering organisation	An engineering organisation exceeding the SME thresholds defined above	Operationalised for this study
QMS implementation	The operational integration of ISO 9001 aligned processes, distinct from certification alone	(Sfreddo et al., 2018); (Heras-Saizarbitoria & Boiral, 2013)
QMS effectiveness	The extent to which the QMS supports compliance, process control, and continual improvement across defined implementation dimensions	Operationalised for this study

1.4.1 Analytical Scope and Delimitations

The study is bounded by four delimitations. Analysis is conducted at the organisational and managerial level, focused on governance structures, leadership involvement, documentation practices, and system level performance monitoring rather than individual operators or isolated production processes. Organisational scope is restricted to manufacturing and engineering-led services, with multinational organisations considered through their engineering operations. The standards frame is ISO 9001:2015, with other management system standards referenced only for contextual comparison. The study is restricted to a single point in time; observation of how QMS maturity develops within organisations over time is outside this study's scope.

2.0 Literature Review

A comparative evaluation of QMS implementation across SME and large engineering organisations must draw on both the theoretical basis for size-contingent management system behaviour and the empirical evidence through which those foundations have been examined. This review synthesises evidence across five analytical themes: organisational typologies and governance structures; resource allocation and capabilities; implementation strategies and size-contingent mechanisms; industry and market context; and comparative findings from prior research. Together, these themes underpin the evaluation framework applied in Chapters 3 through 5 and position this study within the existing literature on mechanism-level QMS implementation effectiveness.

Several sources cited in this review predate ISO 9001:2015 and its substantive revisions to Clauses 4, 6.1, 9, and 10 (ISO, 2015). Each pre 2015 source has been assessed against post 2015 evidence before inclusion. Table 2 summarises the justification for retention.

Table 2: Pre 2015 sources cited in this review, assessed for directional consistency with ISO 9001:2015 aligned evidence prior to inclusion

Source	**Justification for retention**
(Sun & Cheng, 2002)	Size-contingent motivational and governance patterns are directionally consistent with Bravi and Murmura (2021) across two standard revisions
(Levine & Toffel, 2010)	Structural advantage claims for large organisations are consistent with post 2015 comparative evidence
(Prajogo, 2011)	Internal versus external motivation framework is supported directionally by Prajogo et al. (2020) using post 2015 data
(Romano, 2002)	Retained for directional supply chain quality argument; not used to support claims specific to the 2015 standard
(Stephens & Roszak, 2010)	Structural supplier audit argument is consistent with Clause 8.4 governance requirements retained under the 2015 revision

2.1 Engineering Organisation Typologies

Engineering organisations vary significantly in size, structure, and operational complexity, and these differences materially influence how QMSs are implemented and sustained (Al Balushi, 2025; Bravi & Murmura, 2021). Under ISO 9001:2015 Clause 4, organisations are required to consider their internal and external context, making organisational size a structural determinant of supply chain stability, governance formalisation, and the capacity to support specialist quality roles, rather than a proxy for quality ambition or performance (ISO, 2015).

2.1.1 Small Engineering Organisations

Small engineering organisations face structurally embedded compliance constraints under ISO 9001:2015 that empirical evidence consistently attributes to resource, governance, and capacity conditions rather than leadership intent alone. Within engineering sectors such as manufacturing, machining, fabrication, and specialist subcontracting, these organisations typically operate with limited organisational depth and a strong focus on operational delivery (Hudson et al., 2001).

Empirical evidence indicates that SME compliance with ISO 9001:2015 is structurally uneven and most acute where requirements demand proactive planning, systematic monitoring, and structured improvement discipline (Rybski et al., 2017; Chiarini, 2017). This suggests that the 2015 revision's shift towards Risk-Based Thinking (RBT) and evidence-based improvement has disproportionately exposed structural SME governance limitations rather than creating uniform compliance burdens across firm sizes, a position further supported by evidence that certified SMEs frequently satisfy audit thresholds without delivering substantive process improvement (Oliveira et al., 2019).

Table 3: ISO 9001:2015 clause level compliance gaps in SME manufacturing organisations

Clause	Requirement area	Evidence of SME gap	Source
6.1	Risk Based Thinking	Only 30% had proactive risk control measures; structured risk assessment absent in majority	(Rybski et al., 2017; Chiarini 2017)
7.2/7.3	Competence and awareness	Poorly trained workers identified as dominant operational risk source	(Chiarini, 2017)
8/8.4	Operation and supplier control	Supplier nonconformities and process failures among primary unmanaged risk sources	(Chiarini, 2017)
9	Performance evaluation	Only 34% monitored risk management effectiveness; lowest clause compliance scores reported	(Rybski et al., 2017; Handayani et al., 2018)
10	Continual improvement	Certificate oriented implementation without process improvement; weak improvement discipline	(Oliveira et al., 2019)

Note: *Handayani et al. (2018) is included as illustrative single case evidence and should not be treated as generalisable.*

Clauses 6, 9 and 10 collectively constitute the PDCA backbone of ISO 9001:2015, and SME weakness across all three indicates that certification is frequently achieved at the documentation and operational control level while the systemic improvement cycle remains underdeveloped. This has direct implications for the evaluation framework applied in this study, which assesses QMS maturity across audit discipline, corrective action governance, and continual improvement rather than certification status alone.

2.1.2 Large Engineering Organisations

Large engineering organisations hold structural advantages in ISO 9001 implementation through dedicated quality functions, role specialisation and greater capacity to absorb fixed certification costs across documentation, training, and audit infrastructure (Levine & Toffel, 2010; Bravi & Murmura, 2021). These conditions support more systematic and sustained implementation. Bravi and Murmura (2021) confirm that larger firms report higher QMS maturity and perceive certification benefits more intensely with increasing size. However, structural advantage does not translate consistently into superior maturity outcomes. Wolniak (2019), in the largest available cross size maturity comparison at n=537 ISO 9001 certified Polish organisations, finds a statistically significant but nonlinear size effect in which small firms achieved the highest overall maturity scores. Large firms were lower, directly contradicting the assumption that scale advantages produce proportionally superior implementation maturity. Sun and Cheng (2002) compound this by finding no significant relationship between ISO 9000 certification and business performance improvement in large manufacturing firms, indicating that structural formality does not guarantee operational benefit. Multi-site complexity introduced a further qualification; maturity outcomes in large organisations vary by governance design and motivational alignment across sites rather than resource availability alone, meaning scale advantage is contingent rather than structural (Hedberg et al., 2025).

Table 4: Large engineering organisation structural position and contradicting evidence under ISO 9001:2015

ISO 9001:2015 dimension	Large firm structural position	Contradicting evidence
Process formalisation	Dedicated quality roles; structured process-oriented governance (Sun & Cheng, 2002)	Formality does not guarantee performance improvement (Sun & Cheng, 2002)
Audit governance	Embedded audit infrastructure; second party supplier audit capability (Levine & Toffel, 2010)	Inconsistent maturity across dispersed sites (Hedberg et al., 2025)
QMS maturity	Higher reported maturity and benefit perception with size (Bravi & Murmura, 2021)	Small firms outperform large firms on maturity scores in certified organisations (Wolniak, 2019)
Continual improvement	Systematic CAPA governance; management review infrastructure (Levine & Toffel, 2010)	Certificate oriented focus may persist regardless of firm size (Oliveira et al., 2019)

Organisational size therefore functions as a contextual mediator of QMS implementation rather than a determinant of quality outcomes, the analytical foundation upon which the comparative evaluation framework applied in Chapters 3 and 4 is built.

2.2 Organisational Structures and QMS Governance

Organisational size systematically shapes QMS governance structure, with large firms demonstrating stronger formal, process oriented and documentation heavy practices while SMEs rely on informal people centred governance, a pattern that holds across multiple empirical contexts despite variation in national setting and standard version (Sun & Cheng, 2002; Ben Arab, 2020). Ben Arab (2020) demonstrates that size effects are significant for hard practices such as process approach and evidence-based decision making but not for leadership or employee involvement, indicating that the governance gap between firm sizes is structural and systemic rather than cultural or motivational. This distinction matters analytically, SME underperformance in QMS formalisation is a capacity constraint, not a leadership deficit, a position that directly informs how size-contingent differences in the evaluation framework applied in this study should be interpreted.

Taylor and Taylor (2013) confirm in a UK manufacturing context that large firms possess stronger formal system infrastructure, strategy implementation capacity, and information systems support, while SMEs demonstrate compensating strength in management leadership culture. This corroborates Ben Arab’s (2020) finding that size effects concentrate in formal system capacity rather than cultural or motivational dimensions, and confirming this divergence is systematic rather than incidental. Eriksson (2016) and Abad et al. (2016) both extend this argument but require qualification: Eriksson’s findings derive from self-selecting quality award applicants, overstating absolute performance levels, while Abad et al. (2016) operate in an IMS context that may overstate the magnitude of size effects relative to single standard ISO 9001 deployment. Both sources nonetheless support the directional position that organisational size shapes governance capacity primarily through its effect on formal system infrastructure rather than quality intent. The structural divergence is summarised in Table 5.

Table 5: Structural trade-offs between organisational size, QMS implementation, and governance orientation (Sun & Cheng, 2002; Bravi & Murmura, 2021; Ben Arab, 2020)

Organisational size	Governance orientation	Primary constraint
Small engineering organisations	Informal, people centred, leader dependent quality governance	Capacity constraint on formal system infrastructure and documentation discipline
Large engineering organisations	Formal, process oriented, system driven quality governance	Risk of bureaucratic accumulation reducing operational responsiveness

2.3 Comparative Strengths and Weaknesses in QMS Implementation

2.3.1 Quality Assurance and Compliance Standards

ISO 9001 adoption is justified through process consistency, structured quality measurement, and corrective action governance (ISO, 2015), directly addressing process stabilisation and traceability in engineering contexts. Previous literature supports this: ISO 9001 significantly affects internal business processes across 19 reviewed studies (Neyestani & Juanzon, 2017), with operational performance showing the strongest positive relationship across outcome dimensions (Sfreddo et al., 2018). Psomas and Antony (2014) qualify this, finding effectiveness depends on internal motivation and organisational capability rather than certification status, though their Greek manufacturing sample and self-reported measures limit transferability. Whether ISO 9001 is substantively or symbolically implemented is therefore the distinction differentiating the SME and large organisation profiles examined in Section 4.3.

2.3.2 Risk Management Approaches

ISO 9001 Clause 6.1 requires RBT regardless of organisational size, yet implementation depth varies systematically with scale (ISO, 2015). Fonseca et al. (2019), in a quantitative multi country survey of 222 certified organisations, identify RBT as both the principal implementation difficulty and the principal reported benefit, finding that micro companies made slighter adjustments to existing management systems than larger firms, implying a more limited implementation response at the smallest organisational scale. Chiarini (2017), in a mixed method study of 144 European manufacturing SMEs, identifies process risks including production nonconformities, supplier failures, and poorly trained workers rather than broader strategic risk assessment. This focus constrains the coherence of downstream quality planning, corrective action and performance monitoring as an integrated system.

Fonseca and Domingues (2018) present a counterpoint, finding that smaller Portuguese organisations rated ISO 9001:2015 benefits more highly than larger firms. This study is geographically restricted to Portugal and relies on manager perceptions, limiting its transferability and making it insufficient to challenge the implementation depth evidence above. Risk management depth varies with organisational size. SMEs prioritise operational process risks over broader strategic risk assessment rather than the proactive, system wide approach required by Clause 6.1 (Chiarini, 2017; ISO, 2015). This size-contingent divergence is directly relevant to the comparative evaluation in Chapter 3.

2.4 QMS Implementation Strategies in Engineering Organisations

Implementation strategy materially determines adoption difficulty and subsequent internalisation. Simultaneous integration of multiple standards generates higher perceived difficulty than progressive adoption, concentrated in employee related change barriers, though Bernardo et al. (2012) demonstrate that sequence does not necessarily condition integration depth where common procedures are deliberately designed (Abad et al., 2016). Implementation strategy is size-contingent: perceived difficulty decreases as firm size increases, meaning SMEs face greater constraint absorbing formalised requirements and sustaining personnel involvement, and may rationally prioritise core process controls before expanding documentation scope (Abad et al., 2016).

2.4.1 Flexibility and Adaptability in Small Organisations

SMEs face resource scarcity and compressed management structures that constrain implementation capacity while enabling rapid practice diffusion through direct communication (Assarlind & Gremyr, 2016). Adoption progresses iteratively, with ownership developing through incremental experimentation rather than comprehensive rollout, and external consultancy support is often necessary where specialist roles cannot be justified, introducing the internalisation risk discussed in Section 2.6.

Carvalho and Medeiros (2021), in a two company Brazilian SME case study, identify leadership, process approach, evidence-based decision making, and risk management as the dimensions of greatest implementation difficulty, attributing each to limited financial, human, and informational resources that redirect attention toward immediate operational problems rather than formal quality system development. Lean implementation evidence reinforces this pattern: flatter structures aid communication, but weak measurement infrastructure inhibits sustained systematisation (Hu et al., 2015). Where internalisation is absent, decoupling between formal documentation and operational practice may occur, and the conditions driving this outcome are precisely those to which SMEs are most exposed (Heras-Saizarbitoria & Boiral, 2013).

Table 6: SME flexibility mechanisms in QMS adoption and associated risks

Mechanism	Rationale & Evidence	Key Risk	ISO 9001 implication
Contextualised initiation	Senior leadership scepticism shapes adoption; ownership is personal and incremental (Assarlind & Gremyr, 2016)	QMS seen as optional	Alignment of QMS requirements to known operational or supply chain risks to support leadership buy in
Iterative / stepwise adoption	Limited absorptive capacity; 'learning by doing' suits constrained SMEs (Assarlind & Gremyr, 2016; Hu et al., 2015)	Fragmented controls	Progressive implementation prioritising core process controls and corrective action before expanding documentation scope
External support substitution	Dedicated specialist roles not financially viable (Assarlind & Gremyr, 2016)	Dependency; stalled progress post engagement	Time limited external support with structured internal capability transfer
Informal communication as deployment channel	Flat structures enable rapid diffusion (Hu et al., 2015)	Tacit knowledge not retained	Conversion of repeated informal practices into minimal documented standard work
Minimal initial measurement infrastructure	Avoids burden; fits operational pressure (Hu et al., 2015)	Weak evidence of control or improvement	A small KPI set tied to nonconformity and delivery of quality performance

2.4.2 Economies of Scale in Large Organisations

The fixed costs of ISO 9001 adoption partly explain higher uptake and sustainment rates among larger firms, which can absorb documentation, training, and audit infrastructure more readily (Levine & Toffel, 2010). Structural advantage is most evident in second party supplier audit capability, which larger organisations can embed as repeatable governance processes enabling systematic supplier selection and performance monitoring (Stephens & Roszak, 2010). Scale advantage is not unconditional, where processes are aligned to multiple competing standards without deliberate governance integration, reconciliation effort and audit accumulation erode operational benefit (Heston & Phifer, 2011), a risk examined further in Section 2.7.

Table 7: Economies-of-scale mechanisms in large firm QMS implementation and associated trade-offs

Mechanism	**Scale Rationale & Evidence**	**Trade-off if Unmanaged**	**ISO 9001 Implication**
Dedicated internal audit infrastructure	Fixed cost audit competence becomes affordable and repeatable (Stephens & Roszak, 2010)	Audit activity becomes 'compliance heavy' rather than improvement-led	Use audit evidence to drive corrective action, not just pass audits
Supplier governance via second party audits	Large buyers can systematise supplier approval and surveillance (Stephens & Roszak, 2010)	Increased Bureaucracy and transactional friction	Focus audits on risk critical suppliers; align criteria to operational performance
Standardisation across multiple standards/ models	Multi standard environments require explicit governance to reduce redundancy (Heston & Phifer, 2011)	Model proliferation drives documentation and audit costs	Harmonise common procedures; avoid parallel systems
Resource capacity for QMS fixed costs	Larger firms absorb adoption costs and sustain routines over time (Levine & Toffel, 2010)	Formalisation may constrain local flexibility	Balance standard work with local discretion; keep documentation proportionate to risk

2.5 Industry and Market Context

ISO 9001 adoption is frequently interpreted as a response to rising global competitive pressure and supply chain requirements, functioning as a market entry condition rather than a voluntary improvement tool (Priede, 2012). In some markets, certification is explicitly required, in others it operates as a strong buyer preference shaping supplier selection, creating institutional conditions disproportionately influential for SMEs seeking entry into higher tier engineering supply chains (Priede, 2012). Priede (2012) documents global certificate growth across more than 170 countries by 2010 (Appendix B). Sampaio et al. (2009) reinforce this, finding that external motivations dominated ISO 9001 adoption, with certification described by some firms as an imposed condition rather than a voluntary improvement initiative, carrying direct consequences for implementation depth. However, as a pre-2015 literature review, findings reflect broad motivational patterns rather than engineering specific, or size-contingent evidence.

Certification does not, however, guarantee supply chain quality outcomes. Romano (2002) demonstrates that supply chain quality governance is a consequence of internal QMS maturity rather than a driver of it, meaning customer pressure for certification does not automatically cascade upstream and SMEs cannot assume buyer requirements will independently drive quality alignment across their supply base. Fonseca and Lima (2015) further indicate that supplier orientation, mediated by stakeholder satisfaction, determines the performance benefit realised from certification, reinforcing that depth of engagement rather than certification status is the operative variable.

2.6 Outsourcing as a Size-contingent QMS Implementation Mechanism

Whether quality competence is sourced internally or externally represents a context-dependent implementation decision shaped by operational size, resource availability, and governance capacity rather than a deviation from ISO 9001 requirements. Under Clause 8.4, organisations retain full responsibility for the control and effectiveness of externally provided processes regardless of the resourcing model adopted. Clauses 5.1 and 5.3 reinforce that leadership accountability for QMS outcomes is non-delegable (ISO, 2015). Contingency theory supports interpreting external competence reliance as a legitimate adaptation to organisational context rather than a compliance shortcut (Sousa & Voss, 2008; Taylor & Taylor, 2013), a position directly relevant to the comparative evaluation of the Resources and Competence dimension in this study.

The sourcing of quality competence is demonstrably size-contingent. Empirical evidence indicates that micro firms tend to rely predominantly on internal resources during ISO 9001 implementation, whereas SMEs and larger organisations draw more extensively on external information sources and consultants, with consultant use linked to organisational size (Fonseca et al., 2019). While consultants are generally perceived as helpful during the implementation and transition process, their engagement introduces a structural risk specific to SME contexts: where QMS requirements remain unfamiliar to employees and management, the system risks being perceived as external to the organisation rather than embedded within its routines, limiting the internalisation on which sustained performance benefits depend (Lazibat et al., 2022).

Large engineering organisations, with dedicated quality functions and greater capacity to absorb the fixed costs of QMS adoption, are better positioned to sustain audit, corrective action, and competence management activities independently, and are consequently less exposed to this risk (Levine & Toffel, 2010; Abad et al., 2016). For SMEs, reliance on external parties is therefore not simply a resourcing decision but a governance condition that determines whether the organisation ever develops the internal capability to sustain its QMS independently. Prajogo et al. (2020) demonstrate that auditor quality directly strengthens the link between implementation depth and operational outcomes, yet auditor quality does not reliably follow from certification body reputation. SMEs engaging with accredited bodies primarily to satisfy customer requirements have no structural assurance that the audit process will drive genuine internalisation rather than reinforce surface level compliance.

This governance condition has direct performance consequences. Rönnbäck et al. (2009) demonstrate that value destruction is most strongly associated with deficiencies in management responsibility and performance measurement routines across organisational boundaries. Evidence from UK manufacturing organisations further indicates that the performance impact of cross boundary quality governance activities is materially stronger in larger organisations, which possess greater flexibility to invest in supplier evaluation, training, and performance monitoring (Salimian et al., 2017).

2.7 Previous Comparative Studies

2.7.1 Key Findings from Prior Research on Small vs Large Engineering Organisations

Prior comparative research consistently identifies a size effect: implementation difficulty tends to decline as firm size increases, with the sharpest differences in staff involvement and top management participation rather than technical alignment (Abad et al., 2016). Because this evidence is drawn from integrated management systems using multiple standards, the size-based difficulty gap may be overstated for single standard ISO 9001 implementation, though the overall pattern remains consistent with wider QMS literature. Sun and Cheng (2002) found that Norwegian manufacturing SMEs pursued certification mainly under external pressure and relied on informal, people-oriented approaches, whereas larger organisations adopted more structured, process-oriented practices. However, this study predates ISO 9001:2015 and therefore excludes requirements such as RBT, Clause 4 context analysis, and Clause 9 performance evaluation, limiting its direct transferability. Bravi and Murmura (2021), using the current standard, report comparable results: larger organisations show stronger internal motivations and more developed management practices, while smaller firms are more often externally driven and face disproportionate administrative burden. The consistency of these findings across nineteen years and two standard revisions strengthens the size contingency argument, although neither study identifies mechanisms in enough detail to support causal claims.

2.7.2 Lessons Learned and Recurring Themes

Across comparative studies, scale affects QMS outcomes mainly through implementation mechanisms rather than ISO 9001 requirements alone, with externally driven SMEs prioritising compliance over operational integration whilst internally motivated organisations make more rigorous use of audits, corrective actions and performance monitoring (Bravi & Murmura, 2021; Sun & Cheng, 2002). The formalisation trade-off reflects structurally distinct capability profiles rather than unidirectional advantage: SME informality enables responsiveness but limits repeatability under audit scrutiny, while large firm standardisation reduces variability at the risk of bureaucratic accumulation that erodes operational value (Sun & Cheng, 2002; Bravi & Murmura, 2021).

Large firm implementation cannot, however, be treated as homogenous. Hedberg et al. (2025), in a qualitative study of four sites within one multi-site certified organisation, identify QMS archetypes ranging from genuine integration to superficial compliance, shaped by motivational drivers and perceived distance from headquarters rather than resource availability. Although limited by its single company design, the finding is analytically significant; the same mechanisms driving variation between firm size also operate across sites within large organisations, challenging the assumption that scale advantages translate uniformly into implementation maturity.

Table 8: Size-contingent mechanisms shaping ISO 9001/QMS implementation in SME and large organisations (synthesis of comparative evidence)

Mechanism	SME vs Large Constraint	Evidence	Implication
Implementation difficulty	SMEs face greater constraints on staff availability and top management time; large firms can allocate dedicated roles	(Abad et al., 2016)	Size effects are mediated by participation capacity, not just documentation workload
Motivational orientation	SMEs: externally driven (customer/market pressure); Large: internally motivated (process discipline, management development)	(Sun & Cheng, 2002; Bravi & Murmura, 2021)	External motivation increases risk of surface level implementation
Implementation approach	SMEs: informal, people oriented, flexible; Large: structured, process oriented, standardised	(Sun & Cheng, 2002)	Trade-off between responsiveness and procedural control; neither is universally superior
Perceived administrative burden	SMEs report higher burden and difficulty embedding advanced requirements; large firms report higher maturity and benefits	(Bravi & Murmura, 2021)	Reported benefits are contingent on maturity; bureaucracy beyond operational purpose erodes large firm advantage
Multi-site governance	SMEs: typically, single site; Large: site experience varies with HQ proximity and coercive vs enabling standardisation rationale	(Hedberg et al., 2025)	Large organisations should not be treated as uniform; HQ site dynamics shape internalisation

2.7.3 Identified Gaps in Existing Literature

Comparative research often demonstrates size effects without consistently operationalising them into transferable, mechanism-level evaluation approaches. For example, the literature identifies differences in motivations and implementation orientation between SMEs and large firms (Sun & Cheng, 2002; Bravi & Murmura, 2021) and shows that staff and top-management involvement constraints are strongly size-sensitive (Abad et al., 2016). Evidence of this kind, however, frequently stops short of linking these insights to specific routines, such as audit discipline, corrective action effectiveness, and process ownership, that plausibly drive performance differences.

Multi-site governance remains underrepresented within “SME versus large” comparative studies. Many size-comparison studies treat large firms as single-unit organisations, despite the reality that large engineering and manufacturing firms frequently operate as multi-site systems. Evidence from multi-site QMS research suggests that site-level experience and effectiveness can vary with perceived proximity to headquarters and the motivational logic underlying standardisation (Hedberg et al., 2025). This indicates that comparative work focused on size categories alone may underspecify the governance design through which standardisation is implemented and legitimised across sites, a gap particularly salient in engineering firms where operational constraints can differ materially across plants.

While modern evidence aligned with ISO 9001:2015 indicates that different-sized organisations may experience different levels of maturity, burdens, and realised benefits (Bravi & Murmura, 2021), comparative research remains fragmented in terms of constructs and measurements, making it difficult to synthesise outcomes across studies into a single evaluative lens.

2.8 Conceptual Framework

2.8.1 Theoretical Foundations Underpinning QMS Implementation (Contingency Theory, Resource-Based View, Institutional Theory)

A contingency based perspective recognises that firm size, resource availability, and governance structure shape how ISO 9001 requirements are operationalised (Abad et al., 2016; Bravi & Murmura, 2021). Contingency theory holds that management systems must be adapted to organisational context, not universally applied (Sousa & Voss, 2008; McAdam & Miller, 2019). The Resource-Based View (RBV) provides a complementary lens, arguing that competitive advantage derives from internally held capabilities that are valuable and difficult to imitate (Prajogo, 2011). In a QMS context, this means the operational value of ISO 9001 depends on how deeply the standard is internalised into firm specific routines and procedures rather than certification status alone. Prajogo (2011) contrasts internal adoption motives, which build operational capability, with external motives oriented towards legitimacy and market access, finding that internal motives produced stronger performance outcomes. This is directly relevant to this study, where size-contingent differences in resource availability are expected to shape internalisation depth across organisational groups. Sousa and Voss (2008) acknowledge, however, that institutional pressures such as certification requirements and market legitimacy may drive adoption independently of contextual fit, providing justification for incorporating institutional theory alongside contingency theory within this framework.

The availability of internal capabilities and externally sourced expertise shapes compliance pathways and the operational value derived from certification (Abad et al., 2016). RBT, embedded within ISO 9001:2015 Clause 6.1, further provides a lens for evaluating trade-offs associated with different QMS implementation strategies (ISO, 2015). Institutional theory predicts that external adoption pressure produces symbolic rather than substantive implementation, operationalised in the Leadership dimension of the evaluation framework (Heras-Saizarbitoria & Boiral, 2013).

2.8.2 Proposed Framework Linking Organisational Size to QMS Implementation Mechanisms

The proposed conceptual framework positions organisational size as a primary contextual variable influencing the allocation of QMS roles, responsibilities and resources (Abad et al., 2016; Bravi & Murmura, 2021). In accordance with ISO 9001 Clause 5.3, organisations determine how quality related responsibilities are assigned internally or externally, while retaining overall accountability for QMS effectiveness (ISO, 2015).

Clause 7 of ISO 9001 further permits flexibility in how resources and competence are provided, including through external sources, while Clause 8.4 governs the control of externally provided processes, products and services (ISO, 2015). Within this framework, small engineering firms are expected to rely more heavily on outsourced quality expertise to satisfy competence and compliance requirements due to resource constraints (Poksinska et al., 2006; Bravi & Murmura, 2021). In contrast, large engineering firms are more likely to internalise QMS functions through dedicated quality departments and formal governance structures (Sun & Cheng, 2002; Abad et al., 2016).

These size-dependent implementation mechanisms shape the operation of key QMS processes, including documentation control, internal auditing, corrective action management, and supplier quality governance (Sfreddo et al., 2018; Abad et al., 2016).

2.8.3 QMS Implementation Effectiveness and Performance Outcomes

Implementation effectiveness within this framework is assessed not by certification status alone but by the degree to which QMS requirements are genuinely internalised in operational practice, as evaluated against ISO Clauses 9 and 10 (ISO, 2015). Prajogo (2011), drawing on survey data from 328 certified firms, demonstrates that internal adoption motives produce significantly stronger operational performance outcomes than external ones. The implementation-to-performance relationship is moderated internally by adoption motive, with external motives weakening operational outcomes even where implementation activity is present. Prajogo et al. (2020), the most methodologically robust of the three samples at n=537, extend this finding externally, showing that inadequate auditor quality permits symbolic compliance to persist regardless of implementation depth. Taken together, these studies establish that implementation effectiveness is jointly determined by organisational intent and external audit rigour, neither of which is captured by certification status alone. Cai and Jun (2018) qualify this position through configurational analysis of 47 quality managers, finding that the internal motives chain breaks down where a preexisting QMS exists, as the marginal knowledge contribution of ISO 9001 is insufficient to justify full internalisation costs. Although the sample size limits applicability, this boundary condition is relevant to large engineering organisations likely to possess prior quality infrastructure, and suggests that observed performance differences between firm sizes may partly reflect system maturity rather than implementation quality alone.

2.8.4 Summary of Research Gap and Justification for the Dissertation Study

Table 9: Theoretical predictions underpinning the five-dimension evaluation framework and their dimensional operationalisation

Theory	Core claim applied to QMS	Prediction tested in this study	Framework dimension
Contingency theory	Organisational size is a robust structural variable shaping implementation capacity (Sousa & Voss, 2008; Taylor & Taylor, 2013)	Divergence concentrates in structural and procedural mechanisms rather than motivational orientation	Process Formalisation; Audit and Review Practices
Resource based view	Internally held capabilities determine the operational value derived from formal systems (Prajogo, 2011; Sfreddo et al., 2018)	Formalisation depth shapes the profile of improvement outcomes realised rather than whether foundational improvement occurs	Resource and Competence; Continuous Improvement and Realised Impact
Institutional theory	External adoption pressure produces symbolic rather than substantive implementation disproportionately in resource constrained organisations (Heras-Saizarbitoria & Boiral, 2013; Prajogo et al., 2020)	Motivational orientation predicts internalisation depth independently of formalisation level	Leadership and Strategic Commitment

The gap identified in Section 2.7.3 directly determines the analytical structure applied in this study. Existing comparative evidence stops short of translating size-contingent findings into transferable evaluation frameworks (Sun & Cheng, 2002; Bravi & Murmura, 2021), a limitation the five-dimension instrument applied in Chapters 3 and 4 is designed to address.

2.9 Literature Review Summary

The review confirms that implementation depth and governance maturity rather than certification status determine QMS outcomes. However, the comparative evidence base is imperfect. Source limitations documented in Sections 2.7.1 and 2.7.2 mean conclusions rely on directional consistency across studies that differ in national context, standard version, and measurement approach, rather than a unified ISO 9001:2015 specific body of evidence.

The implementation to performance relationship is further complicated by moderating conditions on both sides of the firm boundary. Adoption motive determines whether implementation activity translates into operational benefit, and auditor quality determines whether formal procedures reflect actual practice (Prajogo, 2011; Prajogo et al., 2020). Neither moderator operates reliably where a preexisting QMS exists, which limits how far observed size performance differences can be attributed to implementation quality alone.

The three predictions derived in Section 2.8.4 and summarised in Table 9 directly determine the dimensional structure of the evaluation framework applied in Chapter 3. The five dimensions represent the minimum necessary set to test all the three predictions simultaneously within a single comparative instrument, where any additional dimension considered is either captured within an existing dimension or falls outside the scope defined in Section 1.4.1.

3.0 Methodology

3.1 Research Design Overview

A mixed method design was adopted: quantitative survey items provide comparable measurements of implementation mechanisms across size groups, while open ended responses capture contextual barriers and size contingent constraints that closed response formats cannot adequately represent. The study proceeds in three stages: a literature informed evaluation framework (Section 3.2), questionnaire deployment (Sections 3.3 to 3.4), and comparative analysis using descriptive and nonparametric methods supplemented by thematic coding (Sections 3.5 to 3.6).

3.2 Literature Informed Evaluation Framework

The framework draws on quality management literature and ISO 9001 principles that conceptualise the organisation as an interrelated system of processes, leadership decisions, and resource controls (ISO, 2015), focusing on implementation mechanisms and realised effects rather than certification status.

Dimensions capture both structural and behavioural aspects of QMS implementation (Sun & Cheng, 2002; Bravi & Murmura, 2021), consistent with engineering QMS survey research, grouping quality practices into top management, core, and outcome categories (Rehmani et al., 2020). The five-dimension form adapts that structure for size comparison. Dimensions are operationalised through a mapped set of indicators drawn from mixed measurement types (categorical, ordinal, multi-select, qualitative). Comparisons are therefore reported as dimension profiles rather than a single composite index, preserving interpretability.

Table 10: Literature evaluation framework: dimensions, indicators, and size-contingent predictions for comparative QMS analysis

QMS dimension	Operational definition	Questionnaire Items	Size-Contingent Prediction
Leadership and strategic commitment	The extent to which QMS adoption is strategically motivated rather than compliance driven.	Q6; Q9; Q12	SMEs more likely externally driven; large organisations embed QMS across governance functions and sites
Process formalisation and documented control	Degree of formalised processes, documented information, change communication, and system integration	Q7; Q10; Q14; Q15	SMEs may rely more on informal control; large organisations require standardisation across functions and sites
Resources and competence	Practical capacity to implement and sustain QMS across competence, time, and resource dimensions	Q11; Q18	SMEs: capacity scarcity; Large: coordination and change management burden
Audit, review, and corrective action maturity	Extent to which audit routines are institutionalised, indicated by frequency and CAPA evidence	Q16; Q18; Q20	Large: dedicated audit infrastructure and formal CAPA; SMEs: audit discipline constrained by time and limited specialist roles
Continuous improvement and realised impact	Degree to which QMS is associated with realised improvements and perceived net value	Q13; Q17; Q20	SMEs gain clarity from formalisation; large organisations may realise broader benefits but face bureaucratic load

3.3 Questionnaire Design and Distribution

3.3.1 Scaling and Measurement Logic

Items were selected to cover all five framework dimensions while minimising respondent burden, capturing QMS implementation as aligned indicators rather than a single latent score. Some mechanisms are best represented by ordinal judgements (e.g., perceived influence of organisational size), others by categorical states (e.g., audit frequency, QMS system characterisation, digitalisation bands, and system integration), and others by multi response selections that represent the simultaneous presence of multiple drivers, constraints, and realised outcomes. Open-text items are included to elicit mechanism level explanations and contextual qualifiers that cannot be robustly inferred from closed response formats alone.

Each framework dimension maps to specific questionnaire items (Table 11), reported as evidence profiles rather than a composite index given the mixed measurement type. Question formats were treated per Table 12. Multi-select items (Q9, Q11, Q13, Q17) were expanded into binary indicators (0/1) prior to comparison. Open-text items were analysed qualitatively and triangulated with quantitative patterns.

Table 11: Operationalisation of evaluation framework using questionnaire items

Framework dimension	Questionnaire item(s)	Variable type	Analytical use
Leadership and strategic commitment	Q9; Q12; Q6	Multi-select categorical; ordinal; categorical	Compare strategic adoption drivers (Q9) and perceived size influence (Q12; Q6 used as a contextual condition only)
Process formalisation and documented control	Q7; Q10; Q14; Q15	Categorical; ordinal	Compare QMS characterisation, digitalisation, change communication and MES linkage as formalisation indicators
Resources and competence	Q11; Q18	Multi-select; qualitative	Compare implementation constraints (Q11) and barrier narratives (Q18) as capacity/capability indicators
Audit, review, corrective action maturity	Q16; Q18/Q20	Categorical; qualitative (triangulation)	Compare audit frequency (Q16); triangulate with qualitative references to audit/CAPA limitations
Continuous improvement and realised impact	Q13; Q17; Q20	Multi-select; binary; qualitative	Compare reported outcomes (Q17) and perceived net value (Q13); Q20 explains underlying mechanism
Profiling	Q3; Q4; Q5; Q8	Ordinal/categorical	Describe sample and support contextual segmentation only; not effectiveness indicators

3.3.2 Questionnaire Administration and Deployment Protocol

Instrument development followed three stages informed by recent QMS survey practice (Rehmani et al., 2020). Items were generated from Chapter 2 literature and mapped to the five framework dimensions. After review by the supervisor and Faculty Ethics Committee for relevance, clarity, participant burden, and ethical compliance, the final instrument was deployed via Microsoft Forms (Appendix C).

3.4 Sampling Strategy and Data Collection

Targeted sampling was adopted to recruit individuals able to evaluate practical QMS implementation in engineering contexts (Table 12). This prioritised mechanism level insight over general attitudes or certification status. The questionnaire was distributed through professional networking routes and speculative email invitations to engineering organisations.

Organisational size was determined from workforce banding (primary and sensitivity groupings: Sections 1.4.1 and 4.6.2). Findings are interpreted as comparative patterns within the sample, not population estimates.

3.5 Quantitative Data Analysis

3.5.1 Data Handling and Analysis Decision Rules

Prespecified decision rules ensured consistency and replicability (Table 12).

Table 12: Data handling and analysis decision rules

Component	Rule Applied
Confidentiality	Identifying information (Q2) removed/redacted prior to analysis; not reported
Eligibility and screening	Engineering professionals with QMS exposure included; plausibility screen applied; borderline cases retained, flagged and used for sensitivity re-analysis
Duplicate control	Likely duplicates assessed via timestamp proximity and near identical response patterns; most complete response retained
Missing/partial data	Available-case (pairwise) analysis; denominators reported per comparison; no imputation
Group definition	SME (<250) vs Large (≥250) from Q3; composition reported post-screening
Variable treatment	Ordinal: medians/IQR. Categorical/binary: counts/proportions. Multi-select: expanded to binary indicators (0/1). Open text: qualitative analysis with triangulation
Inferential tests	Ordinal: Mann-Whitney U with rank-biserial effect size (r). Binary/categorical: Fisher's Exact where expected counts are small
Interpretation control	Item level tests treated as exploratory; conclusions prioritise dimension level convergence, sensitivity check consistency, and qualitative triangulation
Framework synthesis	Dimension profiles reported per Table 11 mappings; no single composite score due to mixed measurement types
Sensitivity	Conclusions re-checked under at least one alternative size dichotomy; direction changing findings flagged as non-robust
Reproducibility	Dataset versioning, coding definitions, and analysis outputs retained as audit trail

3.5.2 Data Preparation and Coding

Ordinal items were retained as ordinal, categorical items as nominal, and multi-select items expanded into binary indicators (0/1). Open-text items were analysed qualitatively for triangulation. Where responses were missing, denominators were retained at the item level for transparency.

3.5.3 Group Comparisons and Statistical Tests

Descriptive profiles were produced for each group: ordinal indicators as medians with dispersion, categorical and binary indicators as counts and proportions with stated denominators. Profiling covered QMS characterisation, digitalisation, audit frequency, and reported constraints and outcomes prior to inferential testing.

3.5.4 Dimension Level Modelling Using the Evaluation Framework

Each dimension was operationalised as a normalised score (0-1), scaled by five for reporting. All five dimensions were weighted equally at 20%. Variable notation used in Equations 1-10 is defined in Table 13. The dimension level scoring approach follows the principle of quantifying the QMS implementation against a defined benchmark, applied in recent engineering QMS evaluation research (Rehmani et al., 2023). The 0 to 5 normalised scale used here adapts that principle to a comparative profiling design, where group level differences rather than absolute optimum thresholds are the analytical focus.

Leadership and Resources are not scored on the radar because their underlying questions (Q9, Q11, Q18) are multi-select or open text rather than ordinal, and convert only into binary indicators rather than a continuous 0-5 scale. Both dimensions are therefore carried by the binary indicator profile in Figure 3.

Table 13: Variable notation for dimension scoring equations (scoring is binary unless stated)

Variable	Definition	Variable	Definition
Q7	QMS characterisation score (0-3)	Q10	Document digitalisation score (0-4)
Q14	Change communication method score (0-3)	Q15	Linkage to standard work or MES (binary: Yes=1, No/Not Sure = 0)
		Q13 Variables	
Ben	Benefits outweigh costs	Bur	Bureaucratic
Cos	Costly	Eff	Improves efficiency
Enh	Enhances satisfaction		
		Q9 Variables	
IE	Improves efficiency	CA	Competitive advantage
CS_9	Customer satisfaction – Q9	II	Internal initiative
		Q17 Variables	
FLT	Faster lead times	RE	Reduced errors
Acc	Accountability	Doc	Documentation improvements
CS_{17}	Customer satisfaction – Q17	No_Improvement	Binary indicator: 1 if respondent selected 'N/A', 0 otherwise

Equation 1

$$D_1 = \frac{Q7}{3}$$

Equation 2

$$D_2 = \frac{\left(\frac{Q10}{4}\right) + \left(\frac{Q14}{3}\right)}{2}$$

Equation 3

$$Q13 = \frac{Ben + (1 - Bur) + (1 - Cos) + Eff + Enh}{5}$$

Equation 4

$$D_3 = \frac{(Q15 + Q13)}{2}$$

Equation 5

$$D_4 = \frac{Q16}{3}$$

Equation 6

$$Q9_{proactive} = \frac{IE + CA + CS_9 + II}{4}$$

Equation 7

$$Q17_{Score} = \begin{cases} 0, if\ No\_Improvement = 1 \\ \frac{FLT + RE + CS_{17} + Acc + Doc}{5}, otherwise \end{cases}$$

Equation 8

$$D_5 = \frac{Q9_{proactive} + Q17_{score}}{2}$$

Equation 9

$$Overall = \frac{D_1 + D_2 + D_3 + D_4 + D_5}{5}$$

Equation 10

$$D_{reported} = D \times 5, D \in \{D_1, D_2, D_3, D_4, D_5\}$$

Ordinal outcomes (Q7, Q16) were compared using the Mann-Whitney U test in R (version 4.5.3; R Core Team, 2026), with normal approximation and tie correction applied; the exact method was not used due to tied ranks. Rank biserial correlation (r) was reported as the effect size: small $(|r| < 0.3)$, medium (0.3-0.5), or large (≥0.5). Binary items (Q9) were compared using Fisher's Exact Test (Equation 11), with the two tailed p value representing the probability of a result at least as extreme as observed, and odds ratios reported where estimable.

Equation 11

$$p = \sum_{t} \frac{R_1!\, R_2!\, C_1!\, C_2!}{n!\, a!\, b!\, c!\, d!}$$

Where t = all possible 2×2 contingency tables with the same marginal totals as the observed tables. All hypothesis tests were treated as exploratory at α = 0.05.

3.5.5 Robustness and Sensitivity Checks

Sensitivity checks tested whether conclusions held under alternative analytical specifications: alternative size groupings (to test threshold sensitivity) and item level versus dimension level comparisons (to test construct coherence). Direction changing results were flagged (Appendix E).

3.6 Qualitative Data Analysis

Open ended responses (Q18, Q19, Q20) were thematically coded to identify mechanism level explanations and contextual constraints. The unit of analysis was the individual respondent's response, coded within its originating question.

Coding followed a hybrid approach. An initial deductive codebook was derived from the five evaluation framework dimensions as defined in Table 10. Inductive codes were added where recurring respondent language was not adequately captured by the framework.

Themes were compared across SME and large groups to identify size-contingent patterns in constraints, mechanisms, and trade-offs, then integrated with quantitative results through structured triangulation (Table 18). Extracts are reported anonymously.

3.7 Comparative Modelling and Visual Synthesis

Comparative modelling synthesises the questionnaire outputs into a structured visual comparison of QMS implementation across size groups. Each dimension is represented by a single primary indicator as defined in Table 11, with the maturity model detailed in Section 3.5.4.

Three visual outputs are used. Figure 3 presents a grouped bar dimension profile comparing the prevalence of key indicators across five evaluation framework dimensions by organisational size group. Figure 4 presents a heatmap of Q17 improvement outcomes, expanded into binary indicators and summarised as percentage prevalence by organisational size group; denominators are stated to maintain transparency where missing responses occur.

Figure 2 presents a radar chart of the five-dimension maturity scores on a 0-5 scale across four series: SME primary (n=9), Large primary (n=12), SME sensitivity (n=8), and large sensitivity (n=11). Larger enclosed areas indicate higher scores across more dimensions; convergence between primary and sensitivity series indicates robustness. Enclosed polygonal areas are quantified via the Gauss Area Formula (Equation 12; Appendix G).

Equation 12

$$A = \frac{1}{2}\left|\sum_{i=1}^{n}(x_i y_{i+1} - x_{i+1} y_i)\right|$$

Where $x_i = r_i \cos\left(\frac{2\pi i}{n}\right), y_i = r_i \sin\left(\frac{2\pi i}{n}\right), r_i$ is the maturity score at dimension $(i), n = 5$, and indices are taken modulo n (so $x_{n+1} = x_1$ and $y_{n+1} = y_1$).

3.8 Validity, Reliability, and Ethical Considerations

Ethical approval was granted by the University of Portsmouth Faculty Ethics Committee (ER No. TETHIC-2025-0111895; Appendix A). The study was conducted in accordance with the University's ethical standards, UK GDPR (UK Government, 2016), and the Data Protection Act 2018 (UK Government, 2018; University of Portsmouth, 2024). Participation was voluntary, restricted to individuals over 18, with informed consent obtained prior to participation. No deception, coercion, or collection of sensitive personal data was involved.

Confidentiality and anonymity were maintained throughout. Identifying information was excluded from analytical datasets and is not reported. Research data was stored on the researcher's University of Portsmouth OneDrive account, accessible only to authorised university personnel.

Validity was supported by explicit framework-to-instrument alignment (Table 11) with prespecified indicators and thresholds. Reliability was reinforced through predefined decision rules (Table 12), consistent binary expansion, and transparent denominator reporting. Qualitative reliability was supported by hybrid framework guided coding and structured triangulation.

3.9 Methodological Limitations

Findings support associational comparison rather than causal inference; differences between size groups cannot demonstrate that size causes implementation outcomes. Conclusions are therefore framed as size-contingent patterns supported by qualitative mechanism explanation.

The sample was unconstrained by geography or subsector and is therefore exposed to self-selection and nonresponse biases. Findings are interpreted as context dependent within the achieved sample, not population estimates. Tumiran (2024) identifies participant accessibility, restricted group access, and voluntary participation as constraints, all relevant here given the professional access routes used.

Retrospective power analysis using the exact Monte Carlo method confirmed that Mann-Whitney U tests operated at 40.4% power against a medium effect size ($r = 0.44$) at the achieved sample size (Appendix H). Given this constraint, Cohen's 'r' is reported alongside all test statistics as the primary indicator of substantive effect magnitude, as effect size is independent of sample size whereas p-values are directly influenced by it (Sullivan & Feinn, 2012). Inferential outputs are interpreted through convergence across dimensions rather than treated as standalone confirmatory results.

Measurement limitations reflect reliance on self-reported perceptions and mixed-format indicators. Responses may be influenced by recall effects and social desirability, and do not constitute independent verification of ISO 9001 compliance or audit effectiveness. The instrument was not pretested with target respondents prior to deployment. Supervisor and ethics review provided a lighter form of expert input only. Framework dimensions are not treated as unified scales.

Data quality controls are specified in Table 12 and documented in Appendix E. Optional open text items (Q18 and Q20) may reduce completeness of barrier narratives; however, the mandatory Q19 provides a consistent qualitative basis for size-contingent comparison.

Unmeasured factors including regulatory intensity, product complexity, and supply chain criticality may influence implementation approaches independently of organisational size, and their potential interaction with organisational size prevents observed differences from being attributed to scale alone.

4.0 Results

Quantitative findings are supplemented by qualitative evidence, integrated through a mechanism synthesis in Section 4.5.

4.1 Data Quality, Screening and Analysis Readiness

All submissions were retained following plausibility screening; no exclusions were applied. Flagged borderline cases are documented in Appendix E.

4.2 Sample Profiling and Organisational Context

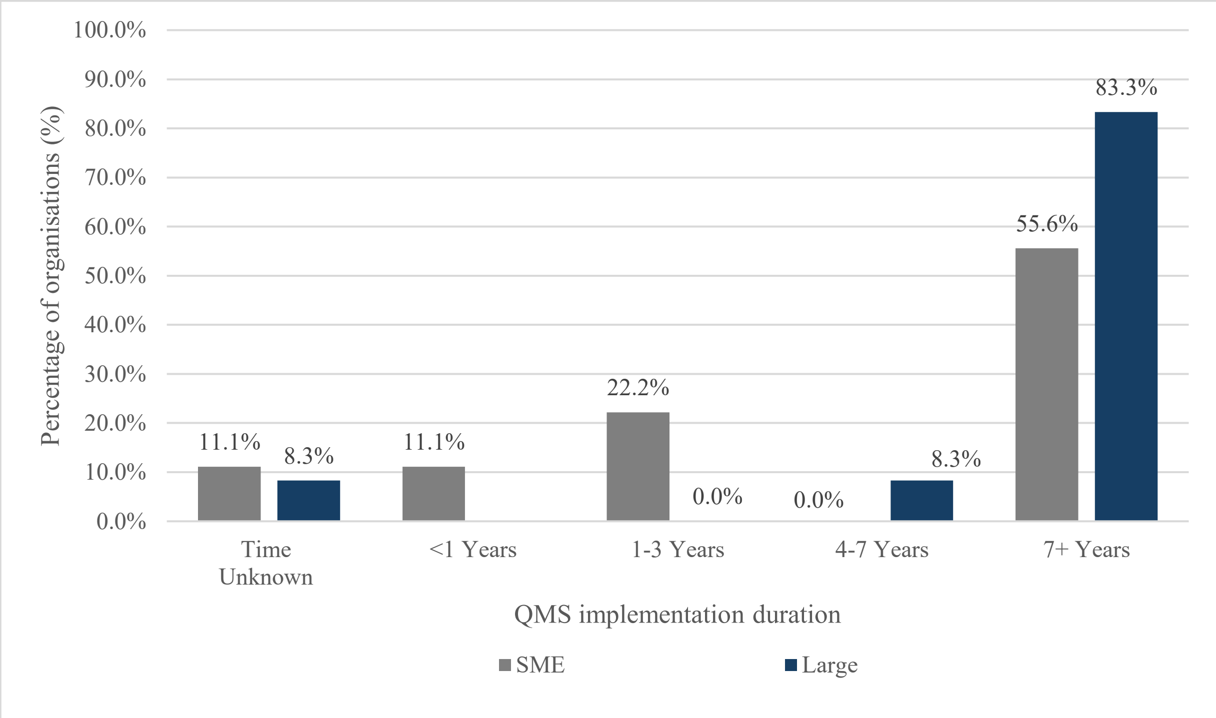
Table 14: Sample characteristics of respondent organisations and professionals by organisational size group

Variable	Category	SME n (%)	Large n (%)
Organisation size	1 Self employed	1 (11.1%)	0 (0.0%)
	2-9 employees	3 (33.3%)	0 (0.0%)
	10-49 employees	2 (22.2%)	0 (0.0%)
	50-99 employees	1 (11.1%)	0 (0.0%)
	100-249 employees	2 (22.2%)	0 (0.0%)
	250-499 employees	0 (0.0%)	2 (16.7%)
	500-999	0 (0.0%)	2 (16.7%)
	1,000-9,999	0 (0.0%)	0 (0.0%)
	10,000+ employees	0 (0.0%)	8 (66.7%)
Primary engineering discipline	Mechanical	1 (11.1%)	3 (25.0%)
	Electrical / Electronic	0 (0.0%)	0 (0.0%)
	Manufacturing	4 (44.4%)	8 (66.7%)
	Multi-disciplinary	1 (11.1%)	0 (0.0%)
	Other	3 (33.3%)	1 (8.3%)
Respondent role	Quality roles	3 (33.3%)	1 (8.3%)
	Engineering roles	4 (44.4%)	3 (25.0%)
	Management roles	1 (11.1%)	7 (58.3%)
	Other	1 (11.1%)	1 (8.3%)
QMS status	ISO 9001 certified	5 (55.6%)	9 (75.0%)
	QMS implemented but not certified	1 (11.1%)	2 (16.7%)
	QMS under development	2 (22.2%)	0 (0.0%)
	No formal QMS	1 (11.1%)	0 (0.0%)
	QMS varies by division *	0 (0.0%)	1 (8.3%)
QMS duration	<1 year	1 (11.1%)	0 (0.0%)
	1-3 years	2 (22.2%)	0 (0.0%)
	4-7 years	0 (0.0%)	1 (8.3%)
	7+ years	5 (55.6%)	10 (83.3%)
	Unknown duration	1 (11.1%)	1 (8.3%)

Note: *Respondent roles were grouped into functional categories to reduce sparsity from highly specific job titles *R01's organisation operates differing QMS structures by division; the response is reported as a separate category but retained in the denominator for percentage calculation.*

Table 14 presents respondent and organisational characteristics. The large organisation group is concentrated largely in firms with 10,000+ employees (66.7%), while SMEs span the lower size bands suggesting ISO 9001 certification is more common among large organisations (75.0%) than SMEs (55.6%).

Figure 1: Distribution of QMS implementation duration by organisational size group



Note: *Percentages are calculated within each organisational size group using available-case denominators.*

Figure 1 illustrates the distribution of QMS implementation duration across size groups. Large organisations display a notably more concentrated duration profile than SMEs, whose responses span a wider maturity range from pre implementation to long established systems; this heterogeneity within the SME group should be considered when interpreting the dimension level findings reported in Section 4.3.

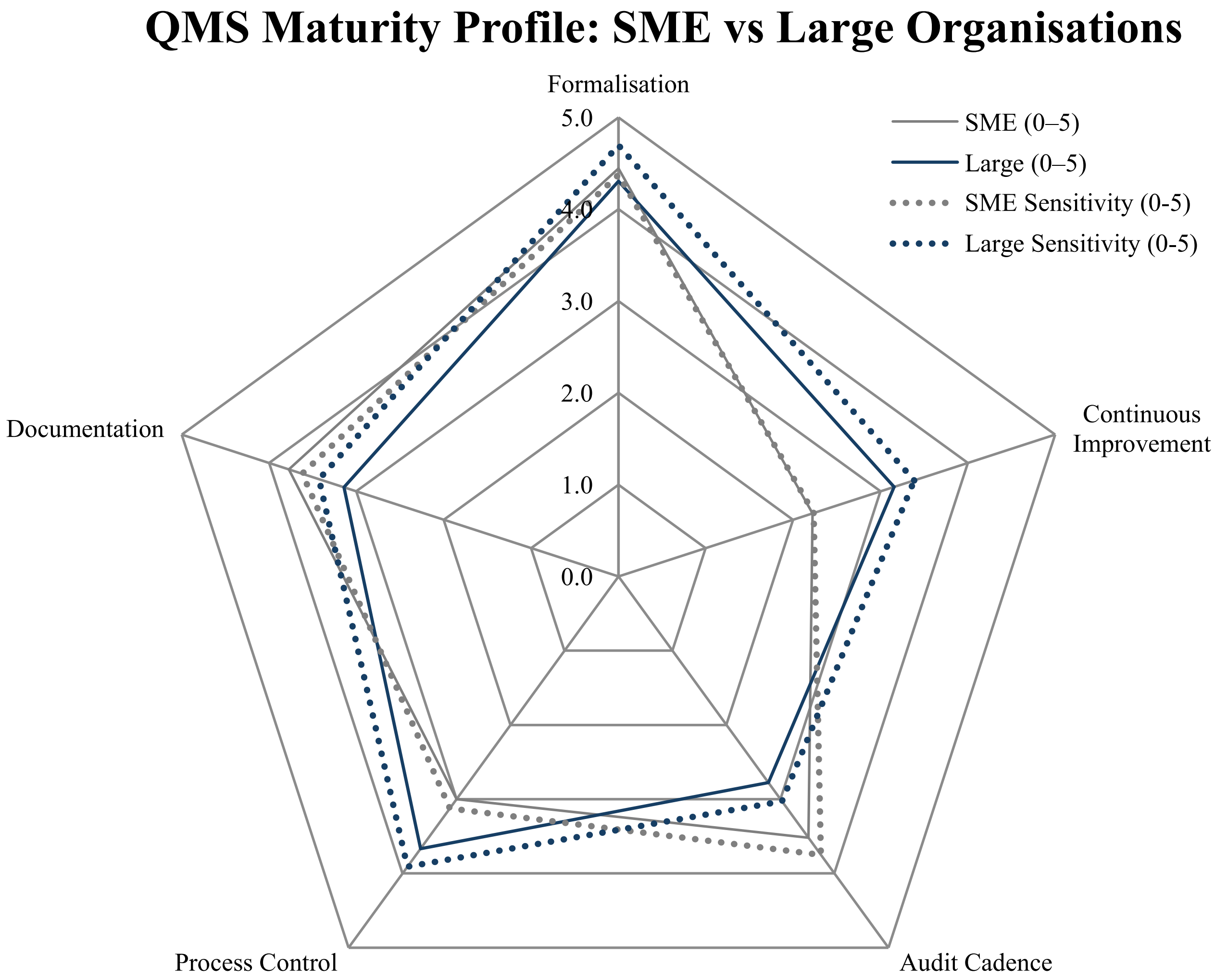
4.3 Comparative Dimension Profile of QMS Implementation

Section 4.3 reports findings across two complementary instruments. Table 15 and Figure 2 present the primary visual and quantitative output for this dissertation, a QMS maturity profile synthesising the quantitative data into a single radar graph, where a greater score denotes implementation maturity and a lower score the inverse. In parallel to this, Figure 3 and Sections 4.3.1 to 4.3.5 present the QMS implementation profile as a binary indicator prevalence framework. The methodological basis for both is documented in Sections 3.5.4 and 3.7. Table 15 dimensions present multiple framework indicators per scoring dimension (Section 3.5.4) and are therefore not fully comparative with Table 10. Indicator level findings in Sections 4.3.1 to 4.3.5 retain primary analytical weight.

Table 15: Maturity model dimension scores by organisational size group (normalised 0-5 scale); sensitivity analysis scores shown in Figure 2 and quantified in Appendix G

Dimension	**SME (n=9)**	**Large (n=12)**	**Δ (Large – SME)**
Formalisation and governance	3.52	5.00	+1.48
Documentation and digital maturity	3.17	3.59	+0.42
Process control and implementation	3.06	3.63	+0.57
Audit frequency	2.59	3.75	+1.16
Continuous improvement	2.56	2.91	+0.35

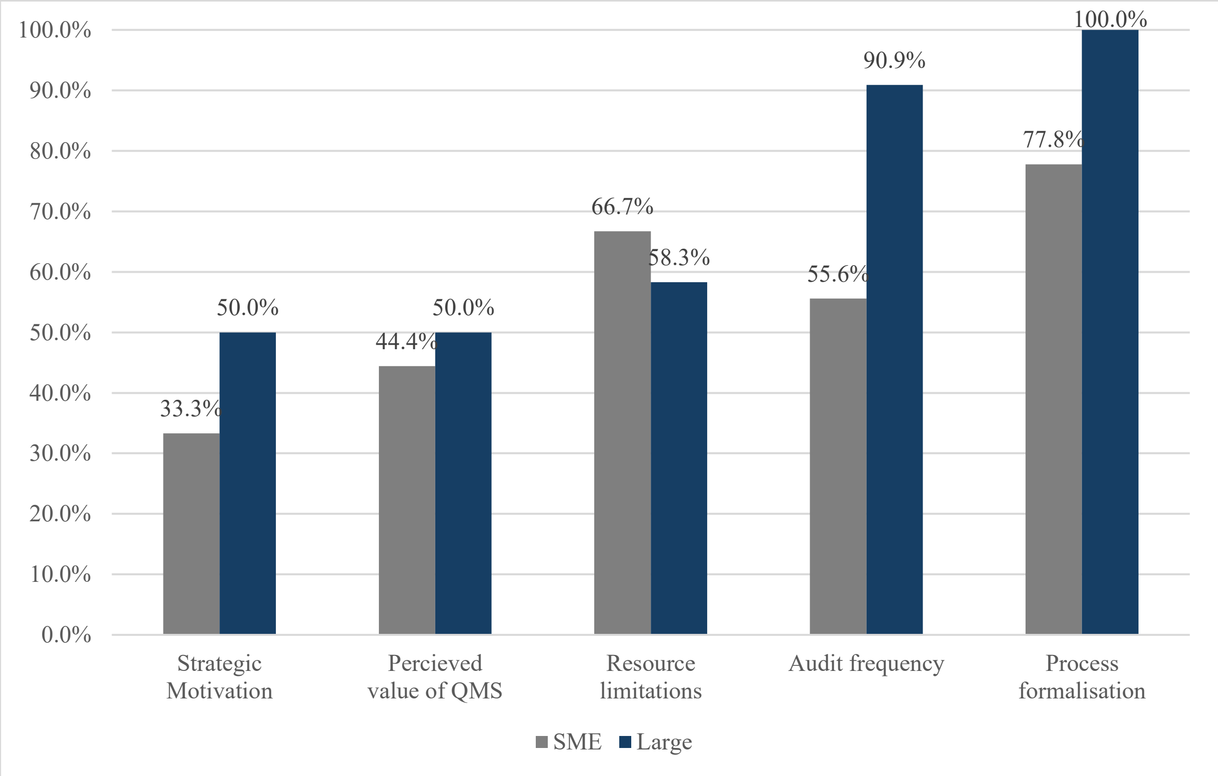
Figure 2: Radar chart of mean QMS maturity scores by organisational size group; results shown before and after sensitivity checks



***Note:** Enclosed polygon areas (units²) calculated using Equation 12 (full workings in Appendix G). SME primary: 21.11; Large primary: 33.30; SME sensitivity: 23.10; Large sensitivity: 33.14; maximum achievable 59.44.*

Table 15 and Figure 2 present mean QMS maturity scores across five scorable dimensions (separate to the evaluation framework dimensions). The largest observed gaps are in Formalisation and Governance, and Audit frequency. Comparatively, Continuous Improvement returns the smallest difference between organisational sizes. While SME scores decrease progressively across all five dimensions, the large organisation profile does not follow this pattern.

Figure 3: Comparative strategic and structural conditions supporting QMS implementation by organisational size group



Note: *Indicators represent the proportion of respondents meeting the pre-defined criteria for each dimension, per the questionnaire-to-framework mapping (Table 11)*

Figure 3 presents binary indicator prevalences across the five evaluation framework dimensions, large organisations record higher prevalence across most dimensions, except for Resource and Competence Constraints, where the pattern reverses. Dimension level findings are reported in Sections 4.3.1 to 4.3.5, with underlying indicator values provided in Appendix F, Table 25, Panel A.

4.3.1 Leadership and Strategic Commitment

The Figure 3 leadership indicator shows that internally driven motivations for QMS adoption were reported by three of the nine SME respondents (33.3%) and six of the 12 large respondents (50.0%). Strategic motivation indicators therefore showed modest prevalence in both groups, with large organisations recording a higher proportion of internally driven adoption. The difference of 16.7 percentage points is noted but, given the small sample, should not be treated as a stable size effect.

Fisher's Exact Tests across six Q9 adoption driver items identified no statistically significant differences (all $p \geq 0.198$), with odds ratios ranging from 0.269 to 2.552 (Appendix H, Table 28). These results should be interpreted with caution given that no power estimation was applied to Fisher's Exact Tests at this sample size. These results are consistent with the binary indicator finding, with neither group demonstrating a statistically distinguishable pattern of internally driven adoption motivation at this sample size.

4.3.2 Process Formalisation and System Integration

Process formalisation exhibited the clearest contrast between size groups of all five dimensions in Figure 3. All 12 large respondents (100.0%) met the high formalisation criterion, characterising their QMS as either internally robust or externally contracted, compared to seven of the nine SME respondents (77.8%). This 22.2 percentage point difference was the second largest cross group gap recorded across the Figure 3 indicators, suggesting that system formalisation and integration characteristics vary materially by organisational size within the screened sample.

A Mann-Whitney U test on Q7 returned $p = 0.013$ ($U = 30.0, r = 0.444$), indicating SME Q7 scores ranked below the large group, which was uniformly at the maximum value. The ceiling effect in the large group means the effect size estimate should be read as a lower bound on the rank separation rather than a precise magnitude. The 22.2 percentage point difference in Figure 3 collaborates the same directional pattern. Fisher's Exact Test on the binary formalisation criterion was not significant ($p = 0.171, 95\%\ CI\ [0.000, 3.866]$). The odds ratio was not estimable because of the zero cell in the large organisation group (Appendix H, Table 28).

4.3.3 Resource and Competence Constraints

Resource limitations were selected as an implementation barrier by six of the nine SME respondents (66.7%) and seven of the large respondents (58.3%), a difference of 8.4 percentage points. Resource and competence constraints were therefore frequently reported across both size groups (Figure 3), indicating that this barrier is not exclusive to smaller organisations within the screened sample. Qualitative barrier distributions are reported in Section 4.5.1.

4.3.4 Audit and Review Practices

Figure 3 shows a planned audit frequency reported by five of the nine SME respondents (55.6%) and ten of the 11 large respondents (90.9%), a difference of 35.3 percentage points. Two SME respondents indicated an intention to conduct annual audits but acknowledged that current practice does not yet meet this cadence (R04, R13); these responses were excluded from the planned cadence indicator as they do not reflect current operational practice, though their presence suggests audit formalisation remains an area of active development within a subset of the SME group. A Mann-Whitney U test did not identify a statistically significant difference in Q16 audit frequency scores ($U = 30.5, p = 0.076, r = 0.435$), though the effect size was medium. Fisher's Exact Test applied to the binary planned cadence criterion did not reach significance ($p = 0.127, OR = 0.140, 95\%\ CI[0.002, 1.900]$) (Appendix H, Table 28).

4.3.5 Continuous Improvement and Outcomes

4 of the 9 SME respondents (44.4%) and 6 of the 12 large respondents (50.0%) selected that benefits outweigh costs, a difference of 5.6 percentage points. Perceived value of QMS implementation was therefore mixed, with neither group returning a majority position that benefits clearly outweigh costs. This indicator is reported as a perception-based summary and is not treated as a causal measure of performance impact.

4.4 Improvement Outcomes Associated with QMS

Figure 4: Improvement outcome prevalence heatmap (Q17) by organisational size group

Outcome	SME (%)	Large (%)	Average
Reduced errors	88.9	91.7	90.3
Accountability	55.6	100.0	77.8
Documentation	88.9	66.7	77.8
Customer satisfaction	44.4	66.7	55.6
Faster lead times	11.1	16.7	13.9
N/A	11.1	0.0	5.6

0 100

Figure 4 presents improvement outcome prevalence by organisational size group; outcomes are ordered to reflect a logical QMS results sequence, with darker shading indicating higher prevalence within each group.

4.4.1 Improvement Outcome Distribution

Reduced errors and documentation improvements were the most frequently reported outcomes among SME respondents, whilst reduced errors and accountability improvements were both highest among large respondents. At the lower end, faster lead times recorded consistently low prevalence. A minority of SME respondents selected no applicable improvements (11.1%); no large organisation respondent selected the same option. Full distributions are reported in Table 25, Appendix F, Panel B.

4.4.2 Comparative Improvement Patterns Between Organisation Sizes

Outcome patterns were not uniformly higher in either size group. Accountability improvements recorded the largest cross group divergence at 100.0% among large organisations compared to 55.6% among SMEs, a gap of 44.4 percentage points. The 100.0 % figure includes one respondent (R03) whose open text “uniformity” response was recoded to accountability for analytical consistency (Table 25). Without this recoding the figure is 91.7% and the gap is 36.1 percentage points. Documentation improvements were the only outcome where SMEs reported higher prevalence (88.9%) than large organisations (66.7%). Reduced errors were the most consistent outcome across groups, differing by only 2.8 percentage points.

Directional differences are summarised in Figure 5, Appendix F. Within the SME group, respondents meeting the high formalisation criterion (Q7 $\geq$ 2) reported a broader outcome profile than those who did not (Table 16). The high formalisation subgroup returned a mean Q17 score of 3.43 against 1.00 for the low formalisation subgroup.

Table 16: SME improvement outcome prevalence by formalisation subgroup

Outcome	SMEs with a formal QMS (n=7)	SMEs without a formal QMS (n=2)
Reduced errors	7 (100.0%)	1 (50.0%)*
Documentation improvements	7 (100.0%)	1 (50.0%)*
Accountability improvements	5 (71.4%)	0 (0.0%)
Customer satisfaction	4 (57.1%)	0 (0.0%)
Faster lead times	1 (14.3%)	0 (0.0%)
No improvements reported	0 (0.0%)	1 (50.0%)

Note: *Fisher's Exact Tests were nonsignificant throughout, as expected at n=2. *Results reported by the same respondent.*

4.5 Qualitative Evidence and Implementation Mechanisms

Response rates across the three open text items varied, with Q18 completed by 13 respondents, Q19 by all 21 respondents, and Q20 by 12 respondents. Q19, which was the only mandatory open text item, yielded the most complete response set and provides the primary basis for qualitative comparison between size groups. Response depth varied considerably across items, ranging from single word answers to detailed contextual accounts, and findings are therefore reported at theme level rather than as exhaustive transcriptions.

4.5.1 Implementation Barriers

Table 17: Q18 implementation barrier responses by size groups

Respondent	Group	Reported Barrier
R04	SME	Resource constraints and cost
R08	SME	Time burden of continual QMS record maintenance
R09	SME	Resource and time constraints
R10	SME	Time and resource constraints at early stage of organisation
R15	SME	Resource and time availability
R01	Large	Coordination complexity across multiple divisions and sites
R03	Large	Risks of QMS becoming a procedural formality rather than a functional tool
R05	Large	Resistance to change and cultural adaptation
R07	Large	Employee training
R17	Large	Documentation transfer workload and volume of change requests
R18	Large	Integration of documentation management into existing workloads
R19	Large	Human resource demands of maintaining compliance requirements
R21	Large	Workforce awareness and training

Note: *Responses are reported at summary level. Non substantive responses excluded (SME n=2; Large n=1). Respondents who did not answer Q18 are not included in the table.*

Resource and time constraints were the dominant barrier theme among SME respondents, cited by all five who provided responses. Among large respondents, no single barrier theme was dominant. Training and workforce awareness were cited by two respondents independently, while documentation management burden and compliance resourcing were each raised by separate respondents. One large organisation respondent identified the risk of the QMS becoming a procedural formality as the primary challenge, which is qualitatively distinct from the resource and operational barriers reported by the remainder of the group.

4.5.2 Organisational Size and QMS Adaptation

Q19 was completed by all 21 respondents, making it the most complete qualitative item in the dataset. Within the SME group, the majority indicated that adaptation is appropriate, though the basis for this view varied. Software affordability was identified as a practical constraint by R04, who noted that enterprise level systems are not financially viable for smaller organisations. R06 and R08 cited the structural agility and internal communication advantages of smaller organisations as factors that should inform QMS configuration. R15 described adaptation as necessary given the differing operational needs of organisations at different scales. A minority of SME respondents held the opposing view, arguing that the fundamental principles of QMS are scale independent and that equivalent benefit is achievable regardless of organisation size (R12, R13, R20).

Within the large organisation group, the majority also supported adaptation, though reasoning was oriented towards the structural demands of scale. Dedicated QMS resource, stakeholder complexity and policy volume was cited as drivers of differentiation between size groups (R14, R16, R17, R21). R09 acknowledged that implementation approach differs by size while maintaining that the underlying objectives of the system should remain consistent. R03 identified project diversity rather than organisational size as the more meaningful driver of QMS complexity, noting that systems become unwieldy where the scope of work is highly varied regardless of scale. R19 suggested that smaller organisations may benefit from less digitalised and more visible QMS formats given the relative ease of updating and communicating changes at that scale. A minority of large respondents indicated that the fundamental premise of QMS does not vary with size (R1, R18).

4.5.3 Mechanisms Synthesis Table

Table 18 integrates the quantitative dimension indicators from Section 4.3 with the qualitative themes from Sections 4.5.1 and 4.5.2, providing a triangulated summary of implementation patterns across the five evaluation framework dimensions.

Table 18: Literature evaluation framework: mechanism synthesis of quantitative indicators and qualitative themes by dimension

Framework Dimension	Quantitative Signal (See Table 25)	Qualitative Theme	Illustrative Extract
Leadership and Strategic Commitment	SME 33.3%; Large 50.0%	Internal operational drivers consistent across both groups;	"The QMS works best when it is fully integrated into the business, organisation culture and has leadership support." (R18, Large)
Process Formalisation and Documented Control	SME 77.8%; Large 100.0%	Software cost constraint in SMEs; Stakeholder complexity in large organisations	"Same overall approach but using different software due to cost". (R04, SME)
Resource and Competence Constraints	SME 66.7%; Large 58.3%	Capacity constraints dominant in SMEs; distributed barriers in large organisations	"Micro / early stage start up, time and resources." (R10, SME)
Audit and Review Practices	SME 55.6%; Large 90.9%	Higher larger organisation cadence; audit formalisation developing in SME group	"The QMS system needs an owner to keep driving improvement and engagement." (R17, Large)
Perceived Value of QMS Implementation	SME 44.4%; Large 50.0%	Mixed value consistently; tick-box compliance risk in large organisations	"The challenge is in avoiding its use becoming a tick box exercise." (R03, Large)

Note: *Quantitative signals represent indicator prevalence by size group; full values in Sections 4.3.1 to 4.3.5 and Appendix F, Panel A. Qualitative themes from Q18 and Q19 unless stated. R17 extract from Q20. Spelling errors not reproduced.*

4.6 Sensitivity and Robustness Checks

Given the small, achieved sample size and the use of a pre-defined size threshold derived from regulatory classification rather than empirical optimisation, the primary findings carry an inherent risk of sensitivity to borderline cases and threshold specification. Two checks were applied to assess the stability of the dimension level conclusions reported in Section 4.3.

4.6.1 Flagged Response Sensitivity Analysis

Both flagged respondents were retained in the primary analysis in accordance with the pre-defined decision rules documented in Appendix E (R15: SME; R17: Large). Dimension level indicators were recalculated with these cases hypothetically removed to confirm that their retention does not materially affect the primary findings.

Table 19: Dimension indicator comparison: Full sample vs hypothetically screened sample

Dimension	Full SME (n=9)	Screened SME (n=8)	Full Large (n=12)	Screened Large (n=11)
Leadership and Strategic Commitment	3 (33.3%)	3 (37.5%)	6 (50.0%)	5 (45.5%)
Process Formalisation and System Integration	7 (77.8%)	6 (75.0%)	12 (100.0%)	11 (100.0%)
Resource and Competence Constraints	6 (66.7%)	5 (62.5%)	7 (58.3%)	6 (54.5%)
Audit and Review Practices	5 (55.6%)	5 (62.5%)	10 (90.9%)	9 (90.0%)*

Note: *Perceived value indicator excluded as response level data was not computable under this specification. *R01excluded from audit indicator (response: "varies by division"); Large audit denominator 11 full, 10 screened.*

No material change in the direction of any indicator was observed. The largest movement was in the audit indicator, which increased from 55.6% to 62.5% in the SME group following the removal of R15, whose response indicated audit practice had not yet reached the intended annual audit frequency. All cross-group patterns remained directionally consistent with Section 4.3.

4.6.2 Alternative Size Threshold Comparison

An alternative threshold of 100 employees was applied, reclassifying the two Upper-Medium respondents (R12, R20; 100 to 249 employees) from the SME group to the large organisation group, producing an alternative grouping of SME n=7 and large n=14.

Table 20: Dimension indicator comparison: Standard vs alternative size threshold

Dimension	Standard SME (n=9)	Alternative SME (n=7)	Standard Large (n=12)	Alternative Large (n=14)
Leadership and Strategic Commitment	33.3%	28.6%	50.0%	50.0%
Process Formalisation and System Integration	77.8%	71.4%	100.0%	100.0%
Resource and Competence Constraints	66.7%	57.1%	58.3%	64.3%
Audit and Review Practices	55.6%	42.9%	90.9%	92.3%

Note: *Values represent the proportion of respondents meeting the pre-defined indicator criterion within each group under each threshold specification. Audit indicator excludes R01 ("varies by division"); Large denominators are therefore 11 (standard) and 13 (alternative).*

The direction of all dimension level indicators was preserved under the alternative threshold. The process formalisation gap widened, with the SME indicator falling from 77.8% to 71.4% while the large organisation indicator remained at 100.0%. The resource constraints indicator reversed direction marginally, with large organisations recording a slightly higher figure (64.3%) than SMEs (57.1%), attributable to the reclassification of R12 and R20, both of whom reported resource limitations as an implementation barrier.

4.6.3 Audit Frequency Inclusion Sensitivity

Two SME respondents (R04, R13) reporting an intention to conduct annual audits not yet realised in current practice were excluded from the planned cadence indicator (Section 4.3.4). Including both as planned cadence raises the SME indicator from 55.6% to 77.8% (7/9) and reduces the cross-group gap from 35.3 to 13.1 percentage points. The directional finding (Large > SME) is preserved, but the magnitude is sensitive to this coding decision.

5.0 Discussion

5.1 Size-contingent Implementation Patterns

The five evaluation framework dimensions do not present a uniform pattern of size-contingency. Material divergence between SME and large organisation groups is concentrated in the structural and procedural dimensions of process formalisation and audit frequency, whilst leadership commitment and perceived value indicators showed broadly comparable quantitative distributions. Resource constraints presented quantitative near parity, though qualitative evidence reveals a substantive divergence in constraint type between groups.

Figure 2 visualises the five-dimension maturity profile. The enclosed area of the large organisation series exceeds the SME series by 57.7% (Equation 12; Appendix G), with the difference sustained under sensitivity analysis (43.5%) and across all possible twelve arrangements of dimensions tested (Appendix G, Table 27). Given the five dimensions are not measured on a common construct scale and equal weighting is presentational, the polygonal area is reported as a visual summary rather than a comparative maturity measure. Analytical interpretation rests on the dimension level indicators reported below.

Process formalisation encompasses the mechanisms through which ISO 9001 requirements are operationalised in practice, including documentation, CAPA governance, competence management and management review. This dimension exhibited the largest maturity score divergence across all five dimensions (Table 15, $\Delta = +1.48$). All large respondents met the high formalisation criterion compared to over three quarters of SME respondents (77.8%), a pattern consistent with contingency theory, which holds that structural complexity increases with organisational scale and generates corresponding pressure towards formalised systems (Sousa & Voss, 2008). Large organisations possess the role specialisation, dedicated quality personnel and governance infrastructure necessary to sustain these mechanisms systematically, a structural advantage documented in prior comparative evidence (Poksinska et al., 2006). Within the SME group, qualitative evidence identifies software cost as a practical constraint on formalisation, with one respondent noting that enterprise level systems are not financially viable at a smaller scale (R04), whilst the absence of dedicated quality roles means formalisation responsibilities are frequently absorbed into existing operational positions rather than managed systematically. Among large organisations, the driver of formalisation appears qualitatively distinct, with stakeholder complexity, documentation volume and multi-site coordination demands cited as structural necessities rather than aspirational targets (R14, R16, R17). The formalisation gap therefore appears to reflect divergent structural conditions rather than divergent intent, a distinction reinforced by the leadership convergence discussed below (Sensitivity Analysis: Section 4.6.2).

The audit and review gap reflects the same structural conditions as the formalisation gap. The resource and governance capacity of the large organisations enables systematic operationalisation of ISO 9001 requirements that SMEs in this sample are largely constrained from matching. The significance extends beyond scheduling compliance, since planned audit frequency is the primary mechanism through which nonconformities are identified, corrective action cycles initiated, and management review inputs generated (ISO, 2015). Where audit frequency is irregular, these downstream mechanisms weaken regardless of wider formalisation. Sustaining a recurring audit programme requires embedding of ownership, scheduling, and corrective action follow through, more readily available in larger organisations (Levine & Toffel, 2010). Two SME respondents (R04, R13) acknowledged that current audit practice does not yet meet their intended annual cadence, indicating that audit formalisation is an active developmental aspiration within a subset of the SME group, partially reflecting a capability deficit being addressed (Section 5.3).

Leadership indicators were broadly comparable (Section 4.3.1), suggesting the structural divergence reflects capacity rather than intent. This is consistent with Heras-Saizarbitoria and Boiral (2013), who position implementation gaps, where internal commitment is present, as capability and resource constraints rather than motivational deficits. The pattern also runs against the institutional theory prediction in Table 9, which would expect lower leadership commitment in SMEs given their externally driven adoption profile. The structural gaps therefore appear to reflect what organisations can do rather than what they intend to do. The findings also invert Wolniak's (2019) result that small Polish certified firms outscored large firms on QMS maturity. Direct comparison is limited because Wolniak's "large" category was not broken into employee bands and did not identify multinational firms, whereas this sample's large organisation group is concentrated in 10,000+ employee respondents (Section 4.2). The two "large" groups are therefore not directly comparable.

Resource and competence constraints were reported at near parity across groups (Section 4.3.3), challenging the assumption that this barrier is exclusive to SMEs. The nature of constraints differs by group. Within SMEs, barriers were characterised in terms of capacity scarcity, with limited time, personnel, and financial resource (R04, R08, R10, R15). Large organisations reported distinct themes: training volume, compliance resourcing, documentation transfer workload (R07, R17, R19), reflecting the administrative burden scale itself imposes. This matches Abad et al. (2016), whose internal barrier framework identified human resource shortages and governance constraints as capability dependent factors expected to diverge by size. The quantitative near parity therefore obscures a qualitative divergence, offered cautiously given limited qualitative responses per group.

Perceived value was mixed across both groups, with neither returning a majority that 'benefits clearly outweigh costs' (SME 44.4%; Large 50.0%). Qualitative evidence in the large organisation group adds analytical depth: two respondents characterised the QMS in bureaucratic terms whilst acknowledging operational benefit (R17, R19), and one identified the risk of the system becoming a procedural formality rather than a functional tool (R03), an expression of the symbolic adoption risk identified by Heras-Saizarbitoria and Boiral (2013). Despite the structural advantages identified above, the frequency of mixed perceived value supports the position of Bravi and Murmura (2021) that governance and resourcing, rather than organisational scale alone, determine the operational benefit realised; symbolic compliance risk is therefore not exclusive to smaller organisations. Given the limited power reported in Section 3.9, this similarity cannot rule out a genuine difference.

5.2 Improvement Outcomes and the Formalisation Benefit Relationship

Improvement outcome patterns across the two size groups do not follow a uniform directional trend. Each group demonstrates relative advantage in distinct outcome categories, a distribution consistent with the position of Sfreddo et al. (2018) that QMS performance outcomes vary by dimension and are mediated by implementation maturity and internalisation rather than certification status alone. This pattern is replicated within the SME group, where the seven high formalisation respondents reported a mean of 3.43 outcomes against 1.00 for the two low formalisation respondents (Section 4.4.2), providing the most direct evidence within the sample available for the formalisation outcome relationship stated in Objective 3.

Accountability improvements showed the largest cross-gap divergence (Section 4.4.2), consistent with the governance architecture advantage identified in Section 5.1, consistent with the evidence of Abad et al. (2016) that clearly defined QMS ownership and management review participation institutionalise accountability as a systematic output in larger organisations. Where CAPA governance is embedded and audit cycles are planned and recurring, nonconformities are more consistently assigned, tracked and closed. The audit frequency gap identified in Section 5.1 is therefore consistent with the accountability outcome gap observed here. Irregular audit cycles reduce the frequency with which corrective action processes are triggered, limiting the conditions under which accountability improvements are realised.

Customer satisfaction improvements followed the same directional pattern as accountability (Section 4.4.2). The literature review identifies value realisation to the end customer as contingent on the strength of measurement routines, corrective action ownership and cross boundary communication processes (Rönnbäck et al., 2009). Where these routines are weak, organisations risk a reduced line of sight to the customer, with direct consequences for feedback responsiveness and corrective action effectiveness. The lower prevalence of customer satisfaction improvements among SMEs is consistent with the capacity scarcity barriers reported by SME respondents, which constrain the sustained operation of the measurement and feedback routines through which QMS activity is translated into customer facing outcomes.

Documentation improvements were the only outcome where SMEs reported higher prevalence (Section 4.4.2), an apparent tension with the finding that all large respondents met the high formalisation criterion compared to just over three quarters of SMEs. One reading is that document control represents a discrete benefit realised independently of wider system depth, consistent with Sfreddo et al. (2018) that QMS outcomes are mediated by mechanism level internalisation rather than overall formalisation status. A competing reading is a maturity ceiling: large organisations may have had mature documentation in place before QMS implementation, leaving less marginal improvement to report. The available data cannot distinguish between these explanations, but either way the finding indicates the relationship between size and QMS benefit is not uniformly directional.

Reduced errors represented the most consistent outcome across both groups, reported by 88.9% of SME respondents and 91.7% of large respondents, a difference of only 2.8 percentage points. The near-universal prevalence of this outcome, despite the material formalisation and audit frequency differences identified in Section 5.1, indicates that error reduction is a foundational benefit of QMS implementation across a broad range of implementation depths. This is consistent with ISO 9001 Clause 10.2, which requires organisations to respond to non-conformities and implement corrective action regardless of system maturity (ISO, 2015). The reduced errors convergence, considered alongside the divergent accountability and customer satisfaction outcomes, suggests that formalisation depth shapes the breadth and profile of benefits realised rather than determining whether improvement is achieved at all.

At the lower end of the outcome distribution, faster lead times were reported at consistently low prevalence across both groups, at 11.1% among SMEs and 16.7% among large organisations respectively. The absence of meaningful divergence between groups on these outcomes, combined with their low absolute prevalence, suggests that QMS implementation does not readily translate into operational throughput or process uniformity gains regardless of organisational size. This is consistent with the position that operational value from quality systems is contingent on integration with wider operational mechanisms rather than on compliance activity alone (Heston & Phifer, 2011).

5.3 Implications for Size-contingent QMS Design and Study Limitations

The findings support mechanism level rather than whole system, size-contingent QMS design. This study suggests that organisational size should not mean lower quality expectations for SMEs. It should mean proportionate implementation mechanisms. This divergence in formalisation and audit frequency suggests that support should target how ISO 9001 is utilised in every organisation, not whether core quality requirements apply. For SMEs, the priority is proportionate formalisation, particularly document control, audit frequency, and internal capability transfer. This is consistent with ISO 9001 Clause 7, which permits flexibility in how resources and competence are provided, and with evidence that small organisations may require external competence support where dedicated quality roles are not viable (Poksinska et al., 2006; ISO, 2015).

This implication has limits. The study does not show that SMEs need simpler or weaker QMSs. It shows that the weaker SME profile sits mainly in formalisation and audit frequency, not leadership commitment or error reduction. The practical implication is targeted support for repeatable control mechanisms; it is not relaxation of ISO 9001 expectations. Reduced administrative burden should not justify weaker audits, corrective actions, or document control routines.

For large organisations, the design challenge is different. The sample indicates that formalisation is broadly achieved, but perceived value remains mixed and symbolic compliance risk was explicitly identified. In this sample, large organisations did not lack formal documentation. The substantive concern, as identified in Section 5.1, was whether those routines remained operationally embedded rather than becoming procedural maintenance activity.

The evidence base is uneven. The formalisation gap of 22.2 percentage points and the accountability gap of 44.4 percentage points were preserved under sensitivity checks and supported by qualitative evidence. These findings can support directional implications within the achieved sample. Resource constraints and perceived value showed smaller cross group differences and should not be treated as stable size effects. Their interpretation depends more heavily on limited open text evidence.

The size threshold is also a boundary condition. The alternative threshold of 100 employees preserved the main formalisation and audit patterns but changed the direction of the resource constraint finding. This weakens any claim that SME and large organisations are internally homogenous. Future work should treat size as a graded structural condition rather than a simple binary category.

Size-contingent support should adapt implementation methods to organisational context while preserving quality expectations as the evidence does not support lower standards for SMEs, only proportionate mechanisms.

6.0 Project Evaluations and Conclusions

6.1 Project Evaluations

The mixed-methods questionnaire design produced materially uneven evidential yield. Two dimensions generated distributions sufficient for comparative interpretation. Two others produced differences too small to support directional conclusions without qualitative triangulation, Which therefore functioned as a compensatory rather than planned complement. A maturity scaled leadership integration measure, distinguishing strategic endorsement from operational embedding, would have produced a more discriminating instrument, especially given that the leadership dimension converged rather than differentiating. Using the European Commission regulatory threshold as the sole size boundary introduced the threshold identified in Section 4.6.2. A sector specific threshold alongside would have strengthened classification. These conditions constrained dimension level confidence, partially mitigated but not fully resolved through predefined sensitivity analysis.

The achieved sample of 21 respondents was the principal constraint on analytical confidence. Descriptive comparison and triangulation retained interpretive value, but cross group differences must be read as directional, not population estimates. Prioritising professional network access improved relevance but introduced self-selection risk. Respondents voluntarily engaging with a QMS focused survey may have been more quality aware than the wider population potentially skewing motivation and perceived value responses. Earlier outreach to engineering sector associations or certification bodies would likely have yielded a larger sample. The consequence was uneven: the largest observed gaps retained directional robustness under sensitivity analysis, while near parity findings on resource constraint and perceived value require replication.

The principal instrument shortcoming was Q18, intended to capture qualitative evidence of implementation mechanisms and barriers. The closed items performed consistently, generating sufficient inter group variation on the structurally differentiating dimensions, but Q18 responses were insufficient for robust mechanism level interpretation across all five dimensions. This is a design issue rather than respondent behaviour. Its consequence was most notable in Sections 5.1 and 5.3, where qualitative triangulation was relied upon more heavily. A structured open-response format presenting specific implementation scenarios or prompted categories would have increased consistency and analytical utility without materially increasing respondent burden.

Inferential testing was applied to Q7 and Q16 via Mann-Whitney U tests and to Q9 via Fisher's Exact Tests. Statistical power was insufficient for confirmatory inference at the achieved sample size (Section 3.9; Appendix H). The absence of prospective power calculation represents a design limitation, and qualitative triangulation functioned as a compensatory mechanism where inferential signal was absent, a dependency the limited Q18 response volume only partially resolved.

6.2 Conclusions

This study evaluated whether QMS implementation effectiveness differs between SME and large engineering organisations across five dimensions. The findings confirm that it does, but not uniformly and not always in the direction the theoretical framework predicted.

The three theoretical predictions collectively point to the same underlying finding: organisational size influences QMS implementation through structural capacity, not through motivation or intent. Contingency theory predicted structural divergence, and this was confirmed, with the largest gaps concentrated in formalisation and audit frequency, the two dimensions most directly determined by resource availability. The Resource-based view prediction was also supported: error reduction was near universal across both groups, while accountability and customer satisfaction improvements were more prevalent in large organisations, indicating that formalisation depth shapes which benefits are realised rather than whether improvement occurs at all. The institutional theory prediction was not supported. Leadership commitment was comparable across both groups despite SMEs being more externally driven, suggesting that the implementation gap reflects what organisations can do rather than what they intend to do. This finding runs counter to the institutional theory prediction in Table 9 and is not reflected in the motivational patterns reported by Sun and Cheng (2002) or Bravi and Murmura (2021), suggesting that motivational orientation and structural implementation capacity operate more independently than the existing comparative literature implies.

Objective one was met. The largest organisation radar profile exceeded SMEs by 57.7%, with the largest gaps in formalisation and audit frequency. Objective two was met. SME constraints were capacity based, covering time, personnel, and the absence of dedicated quality roles, while large organisation constraints were coordination based, covering documentation volume, training demand, and multi-site governance. Objective three was partially met as the formalisation subgroup analysis (n=7 vs n=2) is directional only. Objective four was met: SMEs require targeted support for document control, audit frequency, and internal capability transfer, while large organisations require support focused on internalisation and avoiding symbolic compliance.

Prior comparative literature established that organisational size influences QMS implementation. This study advances that position by identifying where size effects concentrate and where they do not. Across five dimensions, size effects were specific to formalisation and audit governance and absent in leadership commitment and foundational improvement outcomes. This dimensional specificity challenges the assumption in undifferentiated ISO 9001 guidance that organisational size is a general predictor of implementation quality, and provides an empirical basis for redirecting size-contingent support toward targeted structural intervention rather than whole-system redesign.

These findings are bounded by the sample, cross sectional design, and self-reported data, and should be treated as directional rather than generalisable. Future research should apply the framework with a larger sample, sector specific size thresholds, and repeated measurement of the same organisations over time to determine whether the formalisation and audit gaps identified here narrow as QMS experience accumulates.

List of Achievements

Project Achievements

1. Designed and distributed a questionnaire to engineering professionals to collect primary data on how QMS is implemented in practice.
2. Built a five-dimension evaluation framework synthesised from literature to score QMS maturity across both size groups in a repeatable way.
3. QMS maturity scores were calculated using a 0-5 scoring model and radar chart polygon areas, finding large organisations scored at least 57.7% higher than SMEs.
4. Process formalisation and audit frequency were found to be the most influenced by organisational size, while leadership commitment showed little difference.
5. Within the SME group, organisations with a more formalised QMS reported considerably more improvement outcomes than those without.
6. Statistical analysis was carried out in R using Mann-Whitney U and Fisher's Exact Tests, with a retrospective power analysis conducted to understand the limitations of the sample size on the conclusions drawn.
7. Full ethical approval was obtained from the University of Portsmouth before data collection began, and the study was conducted in line with UK GDPR and university data protection requirements.

Learning Achievements

1. Competence in mixed methods research design was developed, integrating quantitative survey analysis with qualitative thematic coding and structured triangulation across five evaluation framework dimensions.
2. Proficiency in nonparametric statistical analysis was acquired through the application of Mann-Whitney U tests, Fisher's Exact Tests, and rank-biserial size reporting using R (version 4.5.3).
3. Critical understanding of Contingency Theory, Resource-Based View, and institutional theory was developed and applied to interpret size-contingent QMS implementation patterns in engineering organisations.
4. Skills in questionnaire instrument design were strengthened, including item mapping to a theoretical framework and scaling logic for mixed format survey data.
5. The ability to critically evaluate and synthesise academic literature across studies with differing national contexts, standard versions, and methodological quality was significantly enhanced through the literature review process.
6. Professional understanding of ISO 9001:2015 implementation practice was deepened through direct engagement with engineering professionals across both SME and large organisational contexts.

Appendices

Appendix A: Certificate of Ethics Review

UNIVERSITY OF PORTSMOUTH

Certificate of Ethics Review

Project title: Evaluating the Implementation of Quality Management Systems in Small vs Large Engineering Firms

Name:	Adam Munn	**User ID:**	UP2061013	**Application date:**	29/10/2025 14:20:59	**ER Number:**	TETHIC-2025-111895

You must download your referral certificate, print a copy and keep it as a record of this review.

The FEC representative(s) for the **School of Electrical and Mechanical Engineering** is/are **Giles Tewkesbury, Jovana Radulovic, Doran Hunter-Haas, Shamsul Masum**

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

- University Policy
- Safety on Geological Fieldwork

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

Supervisor Review

As supervisor, I will ensure that this work will be conducted in an ethical manner in line with the University Ethics Policy.

Supervisor comments:

Supervisor's Digital Signature: [redacted] Date: **13/11/2025**

Faculty Ethics Committee Review

Ethics Rep comments:

Faculty Ethics Committee Member's Digital Signature(s): [redacted] Date: **13/11/2025**

Appendix B: ISO 9001 Global Diffusion Statistics (Priede, 2012)

ISO 9001 has achieved extensive global diffusion, supporting its role as a de facto international baseline for quality system formalisation. Reported trends show sustained growth in both the number of countries adopting ISO 9001 and the total number of issued certificates over the period 1993-2010, exceeding one million certificates by 2010. A temporary reduction in certificate counts is reported during the early 2000s, attributed to the transition between standard revisions, indicating that revisions can generate short term implementation disruption, even when long term adoption continues to rise (Priede, 2012).

Regional adoption patterns also indicate that ISO 9001 diffusion has not been uniform. Reported regional shares suggest a relative decline in Europe's proportion of certificates over time alongside significant increases in Far East share, consistent with the interpretation that certification is used as a competitiveness signal in export-oriented growth regions. For engineering firms' operation internationally, these regional trends support the view that ISO 9001 can act as a market entry and legitimacy mechanism, particularly in supply chains where buyer benchmark suppliers against internationally recognised management standards (Priede, 2012).

Table 21: ISO 9001 global diffusion indicators (1993-2010) (Priede, 2012)

Indicator	**Early period value**	**2010 value**	**Implementation implication**
Countries with ISO 9001 adoption	~60 (1993)	~173	ISO 9001 operates as an international baseline expectation
Number of ISO 9001 certificates	~46,571 (1993)	~1,109,905	Certification has become widespread and institutionalised
Notable discontinuity	Drop reported around early 2000s	Recovery and growth thereafter	Standard revision cycles can disrupt certification counts temporarily
Regional share shift	Europe dominant early period	Europe ~47.8%; Far East ~38.6% (2010)	Certification linked to competitive positioning in growth regions

Appendix C: Questionnaire Instrument

The following instrument was deployed via Microsoft Forms for the primary data collection phase of this study. Question numbering reflects the original survey as deployed; administrative questions not relevant to the analytical framework have been excluded, and minor terminological differences between question wording and the dissertation's defined terminology reflect the instrument's design prior to finalisation of the analytical framework. Section headings, question text, question types, and response options are reproduced verbatim from the deployed survey. Three additional items (Q1a-Q1c) were administered for ethical compliance and are not mapped to the analytical framework, as part of the ethics review (See Appendix A).

Table 22: Questionnaire instrument as deployed via Microsoft Forms (February 2026)

Q No	Question	Question Type	Response Options
		Section A: General Information	
3	How many employees work for your company / enterprise?	Multi choice – Select one	Self Employed (1) (2-9) (10-49) (50-99) (100-249) (250-499) (500-999) (1,000-9,999) (10,000+)
4	What is your company's / enterprises primary discipline?	Multi choice – Select one	Chemical Civil/Structural Digital Education Electrical and Mechanical Building Maintenance Industrial/Manufacturing Mechanical
5	What is your primary role within your company / enterprise?	Multi choice – Select one	Engineer/Individual Contributor Engineering Management General Management Managing Director Operations Engineering Operations Management Owner/Managing Director Project Management Quality Assurance Quality Control
		Section B: QMS Adoption	

6	What is your company’s / enterprise’s QMS status?	Multi choice – Select one	Yes (Certified) Yes (Internal) No (Working towards QMS implementation) Not actively seeking accreditation, but do follow general principles Varies by business division and country
7	Which term best describes your company’s / enterprise’s QMS?	Multi choice – Select one	No QMS Basic QMS controlled by spreadsheets (with the aim of improving) Basic QMS controlled by spreadsheets (with the aim of NOT improving) Internally but robust QMS Externally contracted QMS
8	How long has your company / enterprise used a QMS?	Multi choice – Select one	Less than 1 year 1–3 years 4–7 years 7+ years Unknown duration
9	What was your company's / enterprise's motivation for using a QMS?	Select all that apply	Client requirements Improve efficiency Regulatory compliance Competitive advantage Customer satisfaction Internal initiative
10	To what extent is your QMS digital?	Multi choice – Select one	No QMS yet Some instances of paper documents on site Digital with paper backups Instances of paper documents on site with the aim of purging all paper documents Fully Digital We are working on moving all critical documentation to the QMS system
		Section C: Implementation and Challenges	
11	What challenges / roadblocks has your company / enterprise experienced whilst implementing a QMS?	Select all that apply	Cost Training Resistance to change Management commitment Resource limitations None, implemented smoothly
12	To what extent do you think the size of your company / enterprise has influenced the implementation of your QMS?	Multi choice – Select one	Much easier in smaller firms Slightly easier in smaller firms No major difference Slightly easier in larger firms Much easier in larger firms Not sure (no comment)

13	Do you believe any of the below points apply to the implementation of your QMS?	Select all that apply	Bureaucratic Costly Improves efficiency Enhances satisfaction Benefits outweigh costs
14	How does your company / enterprise communicate change notifications?	Open ended	N/A
Q No	Question	Question Type	Response Options
15	Does your QMS link in any way with Standard Work / Work instructions or a Manufacturing Execution System (MES)?	Multi choice – Select one	Yes No Not Sure
	Section D: Continuous Improvement and Impact		
16	How often does your company / enterprise conduct QMS audits?	Multi choice – Select one	As needed Occasionally Every 6 months Quarterly Annually Monthly Varies by division
17	Please select all applicable improvements your QMS has had on your company / enterprise.	Select all that apply	Faster lead times Reduced errors Customer satisfaction Accountability Documentation Uniformity
18	What has been the biggest barrier to implementing a QMS within your company / enterprise?	Open ended	N/A
19	Do you believe that QMS systems should be adapted differently for small vs large engineering firms? Why or why not?	Open ended	N/A
	Section E: Final Remarks		

20	Do you have any additional comments to make?	Open ended	N/A

Appendix D: Variable Scoring Rules

Table 23: Questionnaire response scoring rules and assigned numerical values by variable

Response	Assigned Score
Q7	
No QMS	0
Basic QMS (no improvement focus)	1
Basic QMS (with aim of improving)	2
Robust / mature QMS	3
Q7_High_Formalisation	
Q7 ≥ 2	1
Q7 < 2	0
Q16_Planned_Audit	
Q16 ≥ 2	1
Q16 < 2	0
Q10	
All documents printed on paper	0
Some paper on site	2
Fully digital	4
Q14	
No system	0
Informal / ad hoc	1
Semi structured	2
Formal system	3
Q16	
Not Performed	0
As needed	1
Annual	2
Every 6 months or more frequent	3

Note: *Q14 responses were collected as open text data and coded into the above categories prior to analysis.*

Appendix E: Plausibility Screening

Table 24: Plausibility screening log 1 (flagged cases only)

Response ID	Flag criterion triggered (F1/F2)	Brief justification (one line)
15	F2	Early stage / no QMS status with multiple "not yet/unknown" responses provide limited implementation evidence but is internally consistent and relevant to adoption stage comparison.
17	F1	Open text responses are low clarity / low information (e.g., Q18 / Q19), retained to avoid subjective exclusion and to preserve representativeness of response quality variation.

Flag criteria:

- **F1:** Low information or unclear open text (retained)
- **F2:** High ambiguity/low specificity that reduces comparability (retained)

Appendix F: Supplementary Results Data (Figure 4 & 5)

Table 25: Data underlying Figure 3 and 4 (dimension indicators and improvement outcomes by organisational size group)

Dimension / Outcome	Indicator definition (Panel A only)	SME n (%)	Large n (%)
	Panel A - Figure 3 indicators		
Strategic Motivation	Internally driven motivation present (Q9): Internal Initiative OR Competitive advantage selected	3 (33.3)	6 (50.0)
Process formalisation and system integration	High formalisation QMS characterisation (Q7 ≥ 2): "basic QMS with aim of improving", "internally robust", or "externally contracted"	7 (77.8)	12 (100.0)
Resources and competence constraints	Resource limitations barrier present (Q11): selected "Resource limitations"	6 (66.7)	7 (58.3)
Audit and review practices	Planned audit frequency (Q16): Annual / 6-monthly / Quarterly	5 (55.6)	10 (90.9)
Perceived value of QMS implementation	Net value indicator (Q13): selected "Benefits outweigh costs"	4 (44.4)	6 (50.0)
	Panel B		
Dimension / Outcome		**SME n (%)**	**Large n (%)**
Documentation		8 (88.9)	8 (66.7)
Reduced errors		8 (88.9)	11 (91.7)
Accountability		5 (55.6)	12 (100.0)*
Customer satisfaction		4 (44.4)	8 (66.7)
Faster lead times		1 (11.1)	2 (16.7)
N/A (no applicable improvements selected)		1 (11.1)	0 (0.0)

Note: Percentages are calculated using available-case denominators within each organisational size group. Panel A indicators were operationalised using questionnaire to framework mapping (Table 11). *Panel B outcomes are from Q17 (multi-select expanded into binary indicators prior to summarisation.*R03 (large) used the open text "other" option to select "uniformity" (Q17), this response was recoded into Accountability for analytical purposes.*

Figure 5: Difference heatmap for improvement outcomes (Q17), expressed as Δ prevalence (Large - SME)

Outcome	Δ Large - SME (%)
Accountability	44.4
Customer satisfaction	22.3
Faster lead times	5.6
Reduced errors	2.8
N/A	-11.1
Documentation	-22.2

Note: *Values are percentage point differences calculated as Large (%) minus SME (%). Positive values indicate outcomes reported more frequently in large organisations; negative values indicate outcomes reported more frequently in SMEs. Values are derived from the prevalence results shown in Figure 4.*

Figure 5 provides a directional summary of the outcome differences shown in Figure 4 and is included as supplementary material to support visual comparison without adding additional figures to Chapter 4.

Appendix G: Radar Chart Polygon Area Calculations (Gauss Area Formula)

SME Primary (n=9)

$$A = \frac{1}{2}|8.5543 + 6.3033 + 7.5364 + 9.2163 + 10.6126|$$

$$\Rightarrow A = \frac{1}{2}(42.2229) = 21.11\, units^2$$

Large Primary (n=12)

$$A = \frac{1}{2}|13.8189 + 10.3641 + 12.9284 + 12.3906 + 17.0905|$$

$$\Rightarrow A = \frac{1}{2}(66.5925) = 33.30\, units^2$$

SME Sensitivity (n=8)

$$A = \frac{1}{2}|10.0582 + 6.8816 + 8.3702 + 9.4181 + 11.4698|$$

$$\Rightarrow A = \frac{1}{2}(46.1979) = 23.10\, units^2$$

Large Sensitivity (n=11)

$$A = \frac{1}{2}|13.6191 + 18.0130 + 13.0990 + 12.0513 + 9.4929|$$

$$\Rightarrow A = \frac{1}{2}(66.2751) = 33.14\, units^2$$

Maximum Achievable Area

$$A = \frac{1}{2}(118.8821) = 59.44\, units^2$$

Table 26: Gauss Area Formula results summary by Figure 2 series

Series	Area (Units²)	Proportion of Maximum
SME Primary	21.11	35.5
Large Primary	33.30	56.0
SME Sensitivity	23.10	38.9
Large Sensitivity	33.14	55.8
Maximum Achievable Area	59.44	100.0

To confirm the reported gap is not dependent on dimension ordering, all 12 distinct circular arrangements were tested, the range of the results is shown below.

Table 27: Ordering sensitivity: Selected results from 12 tested arrangements (primary series)

Dimension ordering	SME Area (units²)	Large Area (units²)	Gap (%)
F, CI, A, P, D (Figure 2)	21.11	33.30	57.7
F, D, CI, A, P	21.21	33.80	59.4
F, P, CI, D, A	20.95	33.94	62.0

Note: *Dimension abbreviations follow Table 15. The ordering used in* Figure 2 *returns the minimum gap across all 12 arrangements.*

Appendix H: R Statistical Analysis and Retrospective Power Analysis

H.1 Inferential Tests

All inferential tests were conducted in R (version 4.5.3; R Core Team, 2026) to satisfy the reproducibility requirements documented in Table 12. The code used to generate all outputs is presented below, followed by a summary of results in Table 28.

```
# Mann-Whitney U Tests - Q7 and Q16
sme_q60 <- c(3, 2, 3, 3, 0, 3, 2, 0, 3)
large_q60 <- c(3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3)
wilcox.test(sme_q60, large_q60, exact=FALSE, correct=FALSE)

sme_q130 <- c(2, 1, 1, 2, 0, 2, 2, 1, 3)
large_q130 <- c(2, 2, 2, 3, 1, 1, 2, 3, 2, 3, 3, 3)
wilcox.test(sme_q130, large_q130, exact=FALSE, correct=FALSE)

# Rank-biserial effect sizes
1 - (2 * 30) / (9 * 12)
1 - (2 * 30.5) / (9 * 12)

# Fisher's Exact Tests — Q7, Q9 (six items), Q16
fisher.test(matrix(c(7, 2, 12, 0), nrow = 2, byrow = TRUE)) #
Q7
fisher.test(matrix(c(5, 4, 6, 6), nrow = 2, byrow = TRUE)) #
Q9 Client Requirements
fisher.test(matrix(c(8, 1, 9, 3), nrow = 2, byrow = TRUE)) #
Q9 Improve Efficiency
fisher.test(matrix(c(3, 6, 8, 4), nrow = 2, byrow = TRUE)) #
Q9 Regulatory Compliance
fisher.test(matrix(c(2, 7, 3, 9), nrow = 2, byrow = TRUE)) #
Q9 Competitive Advantage
fisher.test(matrix(c(4, 5, 6, 6), nrow = 2, byrow = TRUE)) #
Q9 Customer Satisfaction
fisher.test(matrix(c(2, 7, 5, 7), nrow = 2, byrow = TRUE)) #
Q9 Internal Initiative
fisher.test(matrix(c(5, 4, 10, 1), nrow = 2, byrow = TRUE)) #
Q16 (Large n=11, R01 excluded)
```

Table 28: R inferential test outputs by variable

Variable	W	p-value	OR	95% CI	r	Significant?
Q7 (Mann-Whitney U)	30	0.013	-	-	0.444	Yes
Q16 (Mann-Whitney U)	30.5	0.076	-	-	0.435	No
Q7 (Fisher's Exact)	-	0.171	-	[0.000, 3.866]	-	No
Q9 Client Requirements	-	1.000	1.237	[0.163, 9.890]	-	No
Q9 Improve Efficiency	-	0.603	2.552	[0.164, 157.034]	-	No
Q9 Regulatory Compliance	-	0.198	0.269	[0.027, 2.101]	-	No
Q9 Competitive Advantage	-	1.000	0.863	[0.057, 9.919]	-	No
Q9 Customer Satisfaction	-	1.000	0.809	[0.101, 6.149]	-	No
Q9 Internal Initiative	-	0.642	0.418	[0.030, 3.739]	-	No
Q16 (Fisher's Exact)	-	0.127	0.140	[0.002, 1.900]	-	No

Note: *Q9 items tested using Fisher's Exact Test; W and r not applicable. R reports the Mann-Whitney U statistic as W; values are equivalent and reported as U throughout the main text.*

H.2 Retrospective Power Analysis

Power was estimated using the exact Monte Carlo method (Mollan et al., 2020) implemented via 'wmwpow' in R 4.5.3 (R Core Team, 2026) with a fixed random seed (set.seed(123)) to ensure reproducibility. The effect size was expressed as $P(X < Y) = 0.72$, converted from rank biserial ($r = 0.44$) using $p = \frac{r+1}{2}$. A normal distribution was assumed for the reference group.

Full console output:

```
Supplied distribution: norm(0,1); n = 9
Shifted distribution: norm(0.824,1); m = 12
p: 0.72
WMW odds: 2.571
Number of simulated datasets: 1e+05
Two-sided WMW test (alpha = 0.05)
Empirical power: 0.404>
```

Table 29: Exact Monte Carlo power estimates by inferential test (Mollan et al., 2020)

Test	Variable	Effect	Observed Power	Required N (total)
Mann-Whitney U	Q7/Q16	r = 0.444	0.404	38

Note: *Required N calculated to achieve the conventional 80% power threshold. Fisher's Exact Tests applied to Q9 are excluded; no validated exact power estimation method was applied at this sample size.*

List of Equations

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