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A multidimensional analysis of strategies for improving New Zealand residential construction productivity

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ABSTRACT

The New Zealand residential construction sector faces significant quality-related challenges that hinder its productivity despite its significant impact on the national economy. This study uses a mixed-methods approach to evaluate the effectiveness of quality management as a strategy in improving New Zealand residential construction productivity. Data were collected from 106 of 305 questionnaires distributed by construction industry bodies. Key findings emphasise three improvement strategies: (1) implementing a productivity certification and training scheme, (2) addressing the industry's prioritisation of time and cost over quality, and (3) enhancing quality management practices. The study confirms the ISO9000 quality management standards and Lean construction methods are widely supported as strategies for improving productivity. The study highlights the need for greater awareness of quality managements' strategic value and the importance of government support and enhanced organisational leadership. Recommendations include the gradual implementation of ISO9000 quality management standards and the establishment of an industry-wide productivity training program. This study uniquely investigates New Zealand residential construction productivity, providing novel insights and recommendations for policymakers, industry professionals, organisations, and construction practitioners to align with global demand and improve productivity through enhanced quality.

1. Introduction

The global construction sector, which constitutes approximately 13 % of the worldwide Gross Domestic Product (GDP), operates within diverse contexts and is characterised by adversarial relationships and complex value chains. The World Economic Forum observes that global construction productivity lags behind other industries, growing only 1 % annually compared to 2.8 % in manufacturing [1,2]. Common industry challenges encompass an ageing workforce [3,4], poor quality a lack of skilled workers [5,6,7,8,9], slow technological adoption and ineffective procurement and contracting methods, which impede productivity improvement [3,12,13,14] and compromise sector performance, all despite technological advancements, continued research, and legislative policy [15]. Furthermore, this global issue is exacerbated by the economic burden of poor quality [5,6,16,17,18,19,20,21,22,23], highlighting the necessity for effective quality management strategies to ensure industry standards and operational efficiency [6,24,25].

It follows that quality management systems, including Total Quality Management with its focus on continuous improvement, Lean Construction, which aims to minimise waste, the Plan Do Check Act cycle's iterative problem-solving approach, and ISO9000 standards for quality management, have been increasingly adopted globally due to their demonstrated efficacy in enhancing productivity and quality. In developed nations, quality management addresses construction inefficiencies [7,26]; however, its effectiveness is influenced by local factors such as regulatory frameworks, workforce competencies, market dynamics, and political cycles [27,28].

While quality management principles are universally applicable, their integration necessitates contextual adaptation, particularly in sectors with high variability, such as residential construction [29], implying that their effectiveness varies regionally, thus necessitating localised research [10,30,31].

New Zealand's residential building sector presents a unique case as localised research in this international context, exemplifying widespread Global issues and specific local factors. The industry is critical to addressing the nation's pressing housing crisis, with estimates suggesting a yearly shortage of over 20,000 homes [32]. This shortage is compounded by systemic inefficiencies in construction processes,

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including high material costs [3,4,12,13], skilled labour shortages, [11,16] an ageing workforce [3,14], continual delays, and poor quality, [5,6,8,9] contribute to widening the gap between housing supply and demand, placing immense pressure on the sector to improve its productivity.

New Zealand faces unique challenges compared to larger economies. An Organisation for Economic Co-operation and Development (OECD) report [33] highlights this predicament, noting that New Zealanders have been working longer hours for more than five decades yet producing less per hour. Productivity growth has declined since the 1970 s, creating one of the OECD's least efficient economies [33].

Adding further context, despite a national quality standard [34], New Zealand's substandard residential construction quality incurs an annual cost of NZD 2.5 billion, consequently increasing consumer expenditure, reducing housing affordability, and lowering living standards [35,36]. This suggests that quality management in this industry is perceived as a reactive compliance tool rather than a proactive competitive advantage [37].

Regulatory, market, cultural factors and traditional resistance to formal practices hinder the adoption of quality management systems, favouring pragmatic, experience-based methods over more formal approaches [38,39,40]. Insufficient workforce education and training on quality management's benefits exacerbate resistance, indicating a need for compelling rationales to motivate stakeholders to adopt structured tools [38,39]. This suggests a preference for practical, on-site problem-solving over formalised quality control, explaining the nation's substantial economic burden from poor quality. The industry's adherence to traditional methods that may not meet contemporary standards is an enduring problem that necessitates tailored solutions for local industry limitations.

Consequently, due to the industry's economic and social importance [9,36,37,41,42,43,44,45], research highlights the urgent need to improve quality and productivity in the local context. While numerous studies have explored productivity in construction globally, there remains a knowledge gap regarding how quality management strategies specifically influence productivity within the New Zealand residential context. Previous research has focused primarily on broad frameworks, models, productivity factors, management strategies, alternative industries, and other less holistic views, leaving a critical need for evidence tailored to the unique characteristics of the New Zealand residential construction sector. A commonality in previous research is that quality is often considered a secondary factor in productivity improvement, not a primary approach [46].

This study aims to fill the identified gap in the literature by examining the effectiveness of quality management strategies in the local sector. It offers novel, evidence-based insights into enhancing productivity within New Zealand's residential construction sector and provides actionable insights for industry practices and policymaking to improve overall industry performance.

2. Literature review

The modern concept of quality management, introduced by Shewhart, Deming, Juran, Crosby, Feigenbaum, and Ishikawa in the early nineteenth century, offers distinct quality management models [47]. Quality is generally defined as achieving product excellence [48], meeting or exceeding customer expectations, providing value for money [49] and being "fit for purpose" [50]. These pioneers share the themes of continuous improvement, customer satisfaction, and employee involvement in achieving sustainable quality standards, advocating for a proactive, systematic approach to quality management. Deffenbaugh [50] simplified the explanation for the construction industry by emphasising measurable continuous improvement and customer satisfaction.

Recognised in manufacturing in the 1960 s and widely adopted in the twentieth century [20], quality management enhances organisational competitiveness [47]. Despite the benefits observed in other industries that use models such as Total Quality Management, Lean production, Six Sigma, and ISO9000, the construction industry lags in adoption, potentially due to perceived high costs and a prolonged industry culture that tolerates defects [51,52]. Nevertheless, quality management strategies are crucial for project and organisational success in construction firms [21].

When applied strategically, these practices prevent defects, reduce quality costs, maximise resources, and enhance customer satisfaction, implying that the benefits of quality management systems outweigh the perceived implementation costs [25,53,54]. Consequently, quality management has developed into a strategic business function [51,53] and a sustainable organisational strategic approach associated with improved productivity [30].

However, research highlights that global quality costs constitute 2–21 % of contract values, indicating persistent issues with ineffective quality management and a reactive rather than proactive approach to managing quality [20,25,55,56].

This underscores the need for improved industry knowledge to understand the effectiveness of quality management strategies in the global construction sector, both in terms of strategic importance and practical application. Despite varied outcomes, numerous quality management strategies are employed globally to improve quality, including Total Quality Management, ISO9001, Lean Construction and the Plan Do Check Act model. Research shows these models can be used individually or in combination, allowing for integration with organisational needs [20] 57].

2.1. Quality management frameworks and models

2.1.1. Total quality management

Total Quality Management emerged in the mid-1980 s as an integrated global management philosophy that promoted its competitive advantage [56]. As a systematic quality management approach, Total Quality Management has evolved slowly in the construction industry, regardless of the socioeconomic context [31,53]. Gupta and Khitoliya [30] suggest Total Quality Management effectively addresses economic trends and organisational needs while confirming its positive impact on competitiveness, customer service, productivity, and organisational culture. Many studies highlight the widespread international examination of the models' effectiveness in improving profits, safety, quality, customer relations, productivity, and reducing rework and delays, although stressing the need for a cultural shift towards a "learning organisation" model to realise the benefits fully [51,53,58,59,60,61,62]. Turner et al. [63] define Total Quality Management as an ongoing, organisation-wide effort to ensure high-quality customer service and satisfaction. Helmold [12] notes that Total Quality Management aims to enhance processes across all departments to produce superior products and services, which could improve productivity in the New Zealand residential construction sector. A 2021 study on Malaysian industrialised building system (IBS) projects, cited by Alawag et al. [64,65], identified leadership as crucial for effective Total Quality Management implementation. Their research proposed a theoretical framework based on critical factors to help stakeholders apply Total Quality Management in IBS projects, indirectly boosting residential construction productivity.

Conversely, a study on the Cooperative of State Employees (CSE) in Lebanon found that while Total Quality Management significantly improved financial performance, it had little impact on managerial performance [66]. This challenges the assumption that Total Quality Management universally enhances all aspects of organisational performance, which is further supported by [67,68] others who suggest that Total Quality Management may negatively impact organisational performance due to misaligning requirements.

However, barriers to implementing Total Quality Management in residential construction include managerial, organisational, and personnel-related issues [31,55,67]. Larger firms in developed countries

may find Total Quality Management more viable because of their capacity to bear training and compliance costs and access to a more skilled workforce. The existing literature suggests that Total Quality Management can improve construction quality and efficiency; however, further studies are needed to confirm its direct effects on residential construction productivity. Understanding these barriers is crucial for successful TQM implementation [69].

2.1.2. ISO9000

International Standards for quality management ISO9000, established globally in 1987, have been widely adopted because of their flexibility [70].

Motivations for ISO9000 certification include enhancing the company image, meeting customer requirements, and improving construction quality and efficiency [71]. The benefits of ISO9000, including improved quality management, productivity, competitive advantage, and its strategic governmental role, are well-documented [72,73,74,75,76]. Shaikh and Sohu demonstrate that ISO9000 benefits construction firms by increasing employee satisfaction and project acquisition rates, reducing material waste, and enhancing quality and productivity, thereby improving its global market reach. ISO9000 certification signals quality, often becoming a prerequisite for clients and tendering processes, aiding market expansion [77,78].

However, Kakouris and Sfakianaki [77] suggested minimal organisational benefits in terms of financial gain from using the ISO9000 framework. Conversely, others disagree and highlight that most studies found a benefit between ISO9000 implementation and various dimensions of organisational performance [79,80,81,82].

Unlike other quality management systems, ISO9000 offers a general framework that enables organisations to develop industry-specific quality assurance systems [71]. Implementation challenges include management attitudes, organisational maturity, regulatory absence, and poor-quality culture [83]. In contrast, technical barriers, such as concerns over audit quality and the lack of mandatory government regulations, hinder effective ISO9000 adoption [72,73,83].

The necessity for construction-specific modifications to the ISO9000 framework to facilitate its application in the residential sector is acknowledged [44]. Adopting quality management models, such as Total Quality Management or Lean Construction, could lessen these issues by promoting collaboration, streamlining processes, increasing transparency, and emphasising process control [84,85]. Despite its potential to enhance customer service, quality, competitiveness, and innovation, challenges such as regulatory decoupling highlight the gap between quality management systems intent and actual site quality [78,84]. Ultimately, the effectiveness of ISO9000 as a quality management system in the residential construction sector depends on cultural adaptation and alignment with sector-specific standards [53,86].

2.1.3. Demings, plan-do-check-act

Deming's Plan Do Check Act model is a widely recognised four-step management method to continuously improve processes and products across sectors. The iterative Plan Do Check Act cycle is particularly vital for refining processes in construction, with its dynamic control of scheduling, quality, and cost underscoring its effectiveness in residential construction [87]. Meiling et al. [88] showed that applying the Plan Do Check Act cycle in residential construction enhanced quality and performance through planning, execution, monitoring, and continuous improvement, enabling companies to promptly identify improvement areas, address issues, and elevate project quality, emphasising the importance of systematic quality management [55].

Nguyen et al. [89] substantiated the efficacy of the Plan Do Check Act approach in residential construction projects, elucidating its advantages, such as minimising defects, enhancing management efficiency, facilitating the learning process for new employees, and improving overall quality and productivity. Taufik [86] observed that the Plan Do Check Act methodology and its variants augmented productivity and quality across diverse industries, including residential construction in the Sri Lankan sector. This evidence suggests that the Plan Do Check Act cycle is a relevant and effective tool for continuous improvement and enhanced productivity in the residential construction sector.

Nguyen et al. [89] agree with Meiling *et al.* [88] and confirmed the Plan Do Check Act's effectiveness in industrialised and less industrialised housebuilding processes, demonstrating the Plan Do Check Act's applicability and success in both. However, Lundkvist *et al.* [55] identified the shortcomings of quality management practices in residential construction and proposed a proactive Plan Do Check Act-based framework to enhance defect management, quality, and efficiency. This framework aims to improve project outcomes by addressing ambiguous data and a lack of standardisation. The results suggest that the Plan Do Check Act's systematic problem-solving and quality improvement approach can benefit the New Zealand residential construction sector. Nevertheless, research efforts highlight the challenges of this model in acquiring sufficient data and the need for specific data analysis expertise, which may hinder practical implementation in residential construction.

Like other quality management models, implementation barriers include institutional and organisational rigidities, varied construction activities, quality control issues, complex industry dynamics, and a need for more understanding and commitment to quality frameworks. Technical and systemic challenges such as industry support and stakeholder buy-in also present obstacles. Addressing these factors is essential for applying the Plan Do Check Act's continuous improvement processes in the sector. However, unlike manufacturing, identifying and addressing root causes in construction is often seen as costly and resource-intensive. This may deter implementation in smaller organisations [56,90] in the New Zealand residential sector. This may imply that the Plan Do Check Act model may face some challenges in adapting to construction contexts relevant to the nature of project-based construction versus the process-based nature of manufacturing. However, recent studies indicate that the Plan Do Check Act cycle and ISO 9000 standards are closely interrelated and can be effectively combined to enhance organisational performance [11,55]. It is worth noting that the Singaporean government addresses this issue in smaller organisations through incentivisation and industry training [20,57].

2.1.4. Lean construction

Lean construction is derived from manufacturing and targets process inefficiency. Franz [90], Oakland and Marosszeky [56] and Sacks *et al.* [91] affirmed that adopting Lean construction reduces waste and enhances safety, quality, and efficiency. Techniques such as the pull approach, work standardisation, visualisation tools, and integrated project delivery (JiT) can further improve waste reduction, client satisfaction, communication, and task management [90,92].

Although the last planner system has been widely adopted, the results vary owing to industry instability [92]. Integrating Lean principles with building information modelling (BIM) enhances construction performance, efficiency, quality, collaboration, costs, and client satisfaction [93,94] implying the Lean methodology significantly enhances residential construction efficiency.

Confirmed by Lekan et al. [93] who suggest combining the Internet of Things (IoT) with Lean methods and Industry 4.0 for a measurable quality management system in housing projects. Adamu and Adulhamid [95] observed a 17.24 % productivity increase and a 6-week earlier completion of Nigerian housing projects using lean techniques. Cairampoma-Caro et al. [96] found that lean tools improved efficiency in Latin American social housing by 50 %, reducing construction time by 20 % for annual projects of 150–200 houses. These studies confirm the efficacy of Lean construction in enhancing residential project efficiency, particularly in social housing, indicating its potential for broader application in diverse settings, including the New Zealand sector. However, Lean construction doesn't explicitly target improved quality.

The challenges in adopting lean construction include quality control issues, cultural and organisational issues, technical and resource-related difficulties, lack of knowledge, technical expertise, long-term philosophy, cultural resistance, financial constraints, high transactional costs from misaligned parties' interests, and inadequate management support [97,98,99,100,101]. Conversely, there is a trend towards integrating Lean methodologies with ISO9000 standards to attain enhanced benefits [102]. Implementing ISO9000 guidelines facilitates organisations in establishing Lean manufacturing processes and advancing towards sustainability [103].

Hence, a comprehensive approach to addressing these barriers through education, training, cultural change, and organisational commitment to lean principles is essential for effective implementation.

2.1.5. Emerging trends in quality management

Global quality management trends in construction involve integrating digital technologies, sustainability practices, and advanced data analytics. For instance, Bittharia and Tiwari [13] emphasised using technology to evaluate QMS to enhance resource utilisation and prevent defects early, thus avoiding structural failures. Adopting advanced BIM improves quality management and offers a high ROI through model-driven quality assurance (QA) and quality control (QC) approaches [97]. Enhanced Internet of Things (IoT) applications and intelligent sensors enable real-time monitoring and better decision-making during construction planning and execution [41]. Sustainability trends prioritise green building certifications and energy-efficient practices linked to quality management [104] alongside Lean construction principles focused on waste reduction and process efficiency[105]. Data analytics and AI are also used to predict risks, optimise resources, and improve QC during construction [76,106].

Robotics in construction offers innovative solutions to productivity enhancement. However, Iqbal et al. [107] assert that the construction sector trails other industries in leveraging robotic applications. Casini [108] highlights advancements in prefabrication and modular construction as critical drivers of robotics integration in construction. Robotics in Construction (RiC) now encompasses additive manufacturing, deep learning, and building information modelling (BIM).

Zhai et al. [109] suggest recent innovations in construction robotics can potentially revolutionise the industry. The field is shifting from innovation to broader implementation, with single-task robots, on-site and off-site robots, and automated construction sites becoming essential for efficiency and sustainability. Additionally, research shows [110] that these technologies can improve productivity, reduce labour and safety risks, and enhance construction quality in residential projects [109]. Ivanov-Kostetskyi [110] agrees with [108,109] that AI-enabled construction robotics, such as IronBOT, TyBOT, and Newmetrix Vinnie, are rapidly advancing. Prieto et al. [111] suggest that multi-agent robotic systems with human-robot collaboration can effectively address construction challenges. Hence, the ageing construction demographic presents unintended opportunities for improvement in the New Zealand sector.

Xiao et al. [112] confirm the direction of future research involves deeper levels of BIM and robotics integration, near-site robotic fabrication, flexible environment adaptation via deep reinforcement learning, and advanced robot-to-robot collaboration. These advancements and cloud-based robotics [113] are expected to address productivity and quality issues in the construction industry, especially in rapidly urbanising countries and ageing workforces [114].

2.1.6. Quality management strategies – New Zealand residential construction

Economic conditions in the mid-1970 s meant quality management was primarily unknown to New Zealand businesses, and the rapid economic policy restructuring by the New Zealand government in 1984 coincided with some corporate quality management acknowledgement. [115]. Quality management was once a national focus for New Zealand, in line with the USA, Japan, and Australia in the 1980 s; however, the shift to a free-market economy in 1984 reduced government involvement, limiting quality management's progress to a struggling industry [116,117]. Nevertheless, quality management is still relevant to the modern New Zealand residential construction sector, and several strategies could be beneficial. For example, Plan Do Check Act, Total Quality Management, ISO9000, and Lean Construction face similar implementation challenges in the New Zealand residential sector. Governmentally, the "free market" economic model hinders necessary government intervention and policy changes conflict with the New Zealand government's aim for a sustainable and high-performing construction sector. Governmental intervention is required to enhance benefits and drive industry-wide quality and productivity improvements for a sustainable approach [37,117]. Thus, aligned with government objectives, there is a need for increased awareness and understanding of the role of quality management strategies and their applications at the industry level [116].

The New Zealand residential construction industry, mainly consisting of change-resistant micro-companies, adopts a reactive stance towards quality management [36,52]. Despite the limited commitment, standardising quality management practices and implementing frameworks are essential for optimisation [118]. Industry fragmentation impedes the stakeholder buy-in necessary for cultural change [42]. Quality management's standardisation is perceived as complex and costly and requires ongoing training. However, regulatory decoupling highlights inconsistent commitment [76] to quality practices. Specific statistical models (Plan Do Check Act) are symbiotic with the ISO9001 framework; however, they require specialised skilled resources, with the demand for trained data analysts posing significant challenges [55]. The industry profile requires more organisational maturity, complicating its implementation [42]. Organisational culture necessitates alignment with quality management principles and strategic change [119]. Models such as Total Quality Management, ISO9000, and Plan Do Check Act require collaboration and a shift in management approach [62,92]. Poor employee culture, regulatory decoupling, and inconsistent quality management practices add to project-level complexity [76]. Therefore, an increased awareness of quality management's strategic purpose is needed.

Regardless, ISO9000 is considered the most adaptable and comprehensive quality management strategy in the construction industry and can be integrated with internal organisational processes, such as Plan Do Check Act, Total Quality Management, and lean construction. Additionally, the ISO9000 framework can guide industry objectives at the government level. Thus, New Zealand policymakers and industry leaders might consider broadly implementing ISO9000 quality management standards through a gradual and structured approach, such as in other countries [20,44]. Quality management strategies improve quality and productivity by ensuring that projects meet standards and reduce errors and rework; however, economic implications and stakeholder preferences complicate the critical relationship between quality management and productivity. Effective quality management requires a multifaceted approach that, when implemented correctly, can significantly improve the New Zealand residential construction sector performance [120,121,122].

However, systematically addressing known barriers enhances quality management effectiveness, fosters industry integration, and promotes sustainable improvements.

2.1.7. A geographic comparison of productivity improvement strategies

Research shows that global construction sectors share common challenges, indicating that productivity improvement hinges on addressing core industry aspects [4,46]. Key issues include an ageing workforce [4], poor quality [5,6,8,9], shortage of skilled labour [11,16] slow technological adoption [3,10,11], ineffective procurement models and adversarial contracting methods, prevalent in Australia, New Zealand, and the UK [3,4,12,13]. Hence, Globally, many countries have

adopted various strategies to boost the construction industry's productivity, yielding mixed results. The following presents a comparative analysis of productivity improvement strategies that can offer New Zealand valuable insights.

2.1.8. United Kingdom productivity strategies

The British government formulated an industrial strategy to enhance productivity within the construction sector, aligning with five key areas: workforce, infrastructure, innovation, business environment, and regional development. This approach addresses strategies focused on artificial intelligence, data-centric economies, future transportation, sustainable development, and demographic ageing [4,11]. The UK administration has proposed legislative amendments prioritising investments in research and development, technology, innovation, workforce education, and sustainability. A crucial policy initiative examines productivity and expansion in small and medium-sized enterprises to address the need for improvement and provide valuable government assistance [4,11]. This approach is considered beneficial in the New Zealand sector.

2.1.9. Australian productivity strategies

Introduced in 2015, the National Innovation and Competitiveness Agenda [3] is a component of the Productivity Roadmap governed by the Productivity Commission. It aims to enhance the construction industry's productivity through innovation, collaboration, skill development, and industry research. The 2021 Productivity Commission report [123] highlights promising outcomes from digital technologies (e.g. BIM) and Lean construction in improving project timelines and cost reduction [123]. Nevertheless, further productivity enhancement is required. The Australian Constructors Association [3] has proposed a National Construction Strategy to improve productivity by 2033 significantly. This 10-step plan, overseen by national policy, involves shared responsibility among government levels, industry stakeholders, and trade unions. It encompasses specific strategies for procurement methodologies, adversarial contracting, technology, and standardised documentation. Similar to policies in the British sector, the strategy addresses the challenges of an ageing construction workforce.

2.2.0. Productivity strategy comparison –New Zealand

The construction industry shares similarities globally, and international methods could boost New Zealand's construction productivity. Addressing an ageing workforce, technology, AI, small to medium enterprise support, and better procurement methods could benefit New Zealand. Unlike Australia and the UK, New Zealand has stopped initiatives like productivity roadmaps and sector accords, necessitating more government support. This leaves productivity improvements solely to the struggling industry. The authors agree with [3,4] that government commitment to construction productivity for long-term societal benefits is a common challenge. However, the construction sector is crucial to New Zealand's economy and living standards and should be a national priority. Singapore exemplifies significant productivity gains through legislative support and industry collaboration, emphasising quality and productivity nationally.

Continual productivity improvement in construction is vital due to its economic impact [46], requiring sector-specific issue resolution. Notably, quality management is absent in the strategies of compared countries despite the costs of poor quality. This implies that governments undervalue quality management for productivity enhancement. However, Singapore's integrated approach has been more effective than other nations' fragmented efforts [45,46].

The authors argue that construction productivity should be a national priority, with government intervention as a positive catalyst for change.

3. Methodology

Aligning with some [124,12,126] who advocate for a systematic approach to ensure rigorous qualitative research findings, this study employs a Mixed Methods (MM) approach grounded in a pragmatic worldview [124]. A survey link was disseminated via five industry organisation membership websites [125,127] to recruit participants. These organisations typically list members' occupations on a "membership scorecard," showing the five prevalent roles: Project Manager, Company/Managing Director, Quantity Surveyor, Construction Manager, and Site Manager. Thus, organisations were chosen based on their members' alignment with the target population.

Primary data were collected through an online questionnaire to examine quality management's effectiveness in improving residential construction productivity. This method was selected for its speed, efficiency, and versatility, particularly in data management and reducing transfer errors [128]. A priori power analysis using G*Power 3.1.9.7 determined a sample size of 305 participants for adequate statistical power. Of the 121 responses received, 15 were invalid, resulting in 106 valid responses. Empirical data suggest a sample rate of 25 % is adequate for robust analysis [127,129].

Probability sampling requires detailed knowledge of the sample population. This study achieves this by mirroring (Table 1) the broader industry population [127], confirming that a cross-functional sample group captures more diverse and in-depth responses [130]. Therefore, probability sampling was used to select participants (Table 1) from various roles in the New Zealand residential construction industry [130].

Collins et al. [130] propose that validity can be assessed by utilising criterion, content, face, and construct validity. Face and content validity were employed in this study and are crucial during questionnaire development and pretesting, which entails frequently evaluating the presentation and relevance of questionnaire items through expert judgment [131]. Vaske et al.'s seminal work, published in 2017, [131] emphasised that reliability assesses the consistency of instrument measurements. Cronbach's alpha was utilised to determine reliability. A Cronbach's alpha coefficient of 0.720 confirmed the suitable internal consistency of the Likert-scale questions (Table 2). A pilot study (n = 7) involving construction professionals from comparable professions within the New Zealand residential sector was conducted to assess the research instrument's validity and reliability [130,132]. Following empirical recommendations; a random sample of approximately 5–10 % of the final sample (n106) size was selected [130,132]. Consequently, a pilot study (n = 7) involving construction professionals within the New Zealand residential sector was conducted to identify and resolve potential issues and further assess the validity and reliability [130,132]. The respondents provided feedback on the wording and usability of the questionnaire, resulting in minor adjustments.

The Qualtrics-developed online questionnaire includes two Likert scales containing 14 statements on construction productivity and quality management, along with three open-ended questions employing mean value analysis and weighted average methods. The Likert scale assesses attitudes or opinions on a five-point scale [133]. Statistical Package for the Social Sciences (SPSS) was used to evaluate data normality using the Kolmogorov-Smirnov test, which indicated a non-parametric distribution. Group differences were examined using the Kruskal-Wallis test, and thematic analysis was conducted on open-ended questions using Microsoft Excel v16.85 [134].

However, online surveys encounter challenges in tracking response

Table 1
Sample size representativeness.

Industry Profession	PM	CM	SM	GM	SUB
N	21	20	22	18	25
Total N	106				

Table 2
Cronbach's Alpha Analysis.

Reliability Statistics		
Cronbach's Alpha[a]	Cronbach's Alpha based on standardized items	N of Items
0.720	0.765	14

[a] Listwise deletion based on all variables in the procedure.

Table 3
Independent −Samples Kruskal −Wallis Test Summary.

Total N	106
Test Statistic	10.884[a]
Degree of Freedom	4
Asymptotic Sig (2-sided test)	0.014

[a] .The test statistic is adjusted for ties.

rates, non-responders, and over-representation [135], affecting data interpretation and research applicability.

Groves & Peytcheva [136] emphasise that non-respondents in online surveys often differ in engagement, accessibility, or interest. Non-respondents typically include individuals with lower motivation, time, or trust in the research process. Their *meta*-analysis [136] found that response rates are unreliable survey quality predictors. Studies [129,136,137] concur that although increasing nonresponse rates are a concern, higher rates do not necessarily result in more significant nonresponse bias, and high-quality surveys can still yield reliable data despite lower response rates. Researchers should consider survey design and implementation factors to minimise potential bias. Other studies [138,139,140] indicate that even with low return rates, bias can be avoided if respondents' characteristics are representative of non-respondents.

This study tackled key methodological issues through appropriate sampling, data analysis, and research design. Following empirical research, [141,142]representativeness was prioritised over response rates to reduce non-response bias. The sampling methods accurately reflected roles in the New Zealand residential construction industry, as shown in Table 1. The final sample was closely distributed, with 106 participants.

Thematic analysis was used for open-ended questionnaire responses. Inductive thematic analysis identifies patterns and themes in qualitative research. Fuchs [143] emphasised its systematic approach of deriving themes from data through iterative reading, note-taking, and coding. This method's versatility across qualitative designs enhances its effectiveness [143]. Proudfoot [144] indicated that combining inductive thematic analysis with quantitative methods in mixed-method research can bridge methodological gaps and generate new theories through abductive reasoning [144]. The method's adaptability and theoretical independence are widely applicable [145].

This research follows Braun and Clarke's [146] six-stage framework for thematic analysis, which can be inductive or deductive, producing semantic or latent themes. Coding was undertaken using Microsoft Excel v16.85. The inductive process starts with data familiarisation and crucial text coding [125,147]. Themes were initially identified before applying an interpretive lens to reveal deeper latent factors [127]. This method allows the narrative to unfold organically, which is suitable for exploratory research [126]. The study presents thematic findings in Tables 5, 6, and 7. An ethics application was submitted and approved (Autec 24/77) for this study. This research evaluated the effectiveness of quality management strategies in enhancing New Zealand residential construction productivity.

4. Results

4.1. Demographic survey results

The nationwide questionnaire targeted New Zealand's residential construction sector. Table 3 highlights the demographic data of 106 participants, including their age groups, professions, industry experience, and education levels.

The sample group characteristics (Table 3) suggest that feedback is reliable and valuable in drawing valid conclusions regarding the New Zealand residential construction sector (Table 3).

4.2. Quality management concerns

Participants (N106) were asked seven questions on a 5-point Likert Scale regarding the effectiveness of quality management in the New Zealand residential construction sector. Fig. 1 confirms three subthemes: QMS and managing quality in organisations, QMS and Organisational culture, and QMS and project parameters. The weighted average of the seven statements is 3.57.

4.2.1. Sub-theme 1: QMS and managing quality in organisations

A mean score of 4.00 indicates that participants predominantly view quality management as reactive in New Zealand's residential construction sector, with 81 % agreeing or strongly agreeing. While 58 % believed that ISO9000 could boost productivity, the mean score of 3.53 reflects a slightly lower perception. The results highlight the need for greater organisational clarity on the benefits, use, purpose, and understanding of Quality Management Systems (QMS) in New Zealand residential construction (Fig. 1).

4.2.2. Sub-theme 2: QMS and organisational culture

Most respondents (61 %) believed that an organisational QMS could enhance New Zealand residential construction productivity, while 30 % expressed disagreement, resulting in a low mean score of 3.52 (Fig. 1). However, only 25 % of the participants concurred that their organisational QMS fulfilled quality objectives, with 75 % either disagreeing (27 %) or remaining neutral (48 %), yielding a low mean score of 2.97.

4.2.3. Sub-theme 3: QMS and project parameters

A mean score of 4.37 indicates participants believe the New Zealand residential construction industry prioritises time and cost over quality, with 96 % of respondents agreeing (53 %) or strongly agreeing (43 %). However, a mean score of 3.41 suggests a low perception that quality management enhances time and cost outcomes. The results confirm that 46 % agree that quality management enhances time and cost outcomes, and 54 % disagree or remain neutral. Moreover, a mean score of 3.21 reflects a low perception of cost as a barrier to implementing a quality management system. The results showed that 51.9 % of participants agreed, and around 44 % disagreed (33 %) or were neutral (10.4 %) Fig. 1).

4.3. Construction productivity and QMS

Participants (N106) were asked questions on a 5-point Likert Scale regarding strategies for enhancing construction productivity in the New Zealand residential construction sector. Fig. 2 identifies five subthemes: Organisational QMS and Productivity, Productivity Training, Productivity as Legislation and Measurement, Productivity and Workflow Collaboration, and Productivity and Organisational Culture.

The weighted average of the seven statements is 3.52.

4.3.1. Sub-theme 4: Organisational QMS and productivity

A mean score of 3.30 confirms participants' low perception (Fig. 2) of improving NZ residential construction productivity by including QM in a.

Project design and procurement phases. Moreover, results highlight that approximately one-third (42 %) of the participants agreed (37 %) or strongly agreed (5 %). Conversely, 43 % were neutral in their responses,

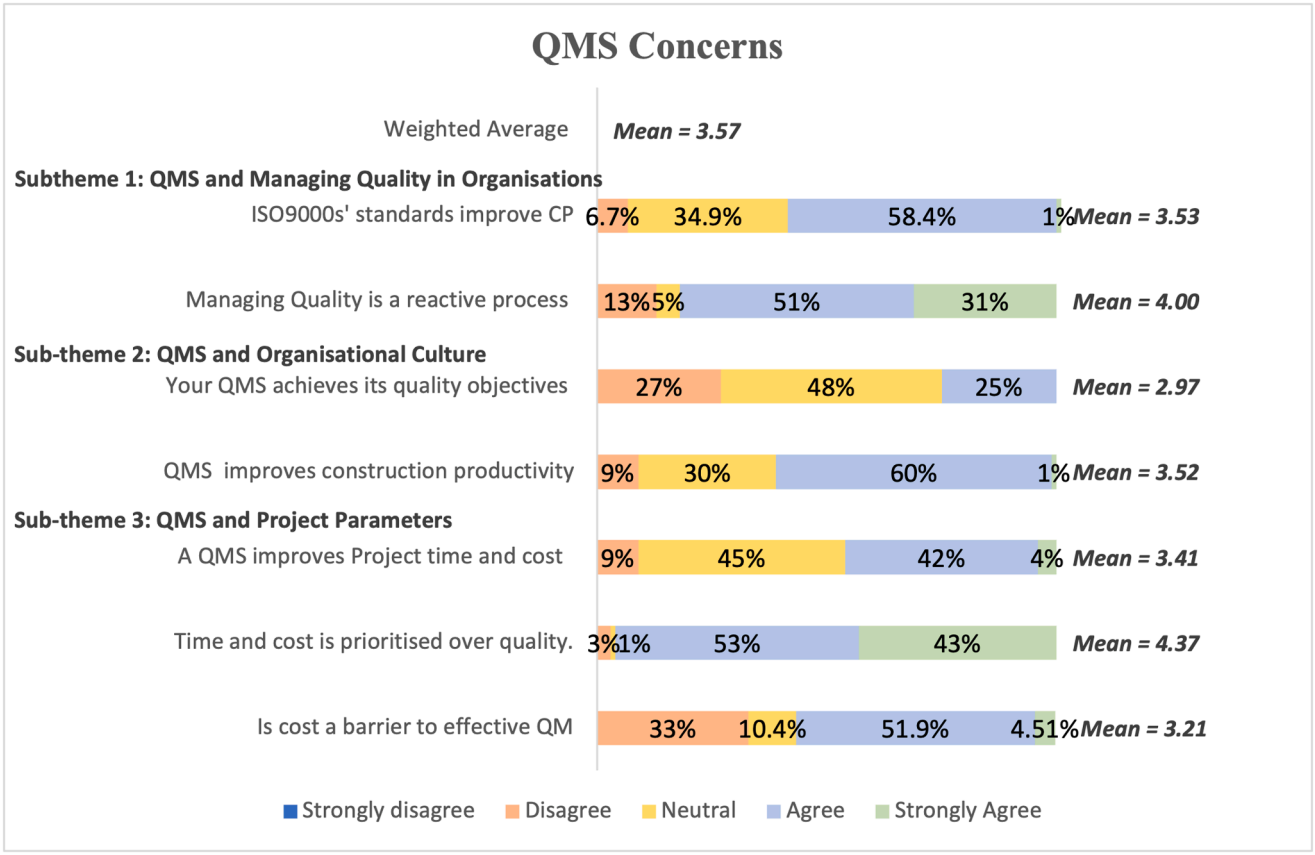

Fig. 1. QMS Sub-themes and Mean Value Indicators.

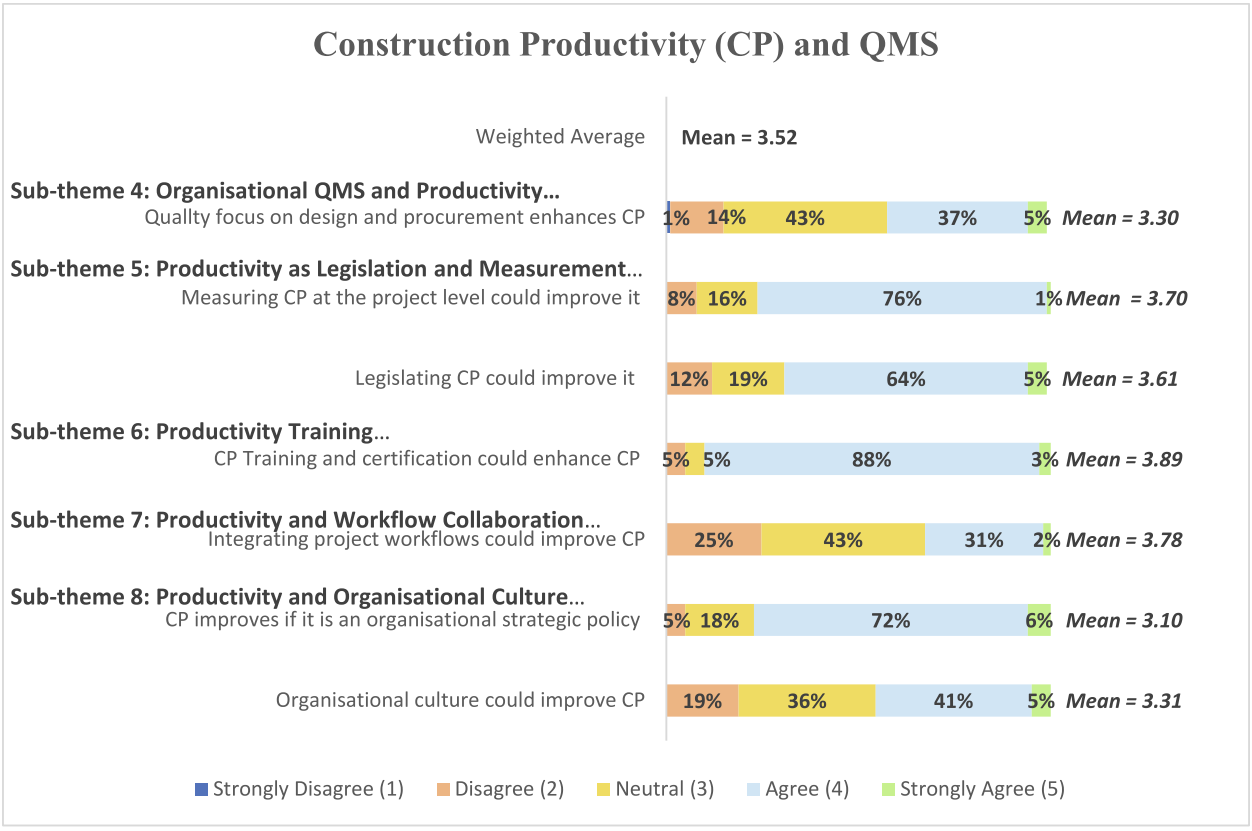

Fig. 2. Construction productivity and QMS sub-themes with Mean Value indicators.

and only 15 % disagreed or strongly disagreed with this statement.

4.3.2. Sub-theme 5: Productivity as legislation and measurement

According to Fig. 2, a mean score of 3.70 indicates a high perception among participants that New Zealand residential construction productivity can be improved if measured at the project level. The results show that 76 % of the participants agree (75 %) or strongly agree (1 %). Conversely, 24 % disagreed (16 %) or strongly disagreed (8 %). Additionally, a mean score of. 3.61 indicates that participants' high perceptions of productivity, such as health and safety, could improve if legislated. Moreover, 69 % agreed (64 %) or strongly agreed (5 %), whereas 31 % either disagreed (12 %) or remained neutral (19 %).

4.3.3. Sub-theme 6: Productivity training

According to the findings presented in Fig. 2, a mean score of 3.89 demonstrates participants' high perception and support for an industry-wide scheme to train and certify construction professionals on improving productivity. Approximately 90 % of participants agreed (87 %) or strongly agreed (3 %) with this statement. On the other hand, only 10 % of the respondents disagreed (5 %) or were neutral (5 %) regarding this statement.

4.3.4. Sub-theme 7: Productivity and workflow collaboration

The mean score of 3.78 signifies participants' high perception regarding the importance of incorporating project stakeholder workflows to enhance New Zealand residential construction productivity. Approximately one-third of respondents agreed (31 %) or strongly agreed (2 %) with this statement. Conversely, approximately two-thirds (67 %) of respondents demonstrated neutrality (42 %) or disagreement (25 %). This finding suggests a disconnect at the project level regarding the benefits of integrated workflows (Fig. 2).

4.3.5. Sub-theme 8: Productivity and organisational culture

Participants' perceptions of improving construction productivity as a strategic organisational policy are low, as indicated by a mean score of 3.10. Nevertheless, 78 % of the respondents agreed (72 %) or strongly agreed (6 %) with this statement, only 5 % disagreed, and 19 % remained neutral. Similarly, a mean score of 3.31 reflects a low perception among respondents that organisational culture could enhance New Zealand residential construction productivity. Only 41 % of the participants agreed, 5 % strongly agreed with this statement, 35 % remained neutral, and 19 % disagreed (Fig. 2).

4.4. The Kruskal Wallis test

Upon analysing the participants' responses, it was essential to determine whether there were different perspectives among the five groups of research participants. Consequently, a Kruskal-Wallis test was conducted (Table 2) based on the following hypotheses:

H0 (null hypothesis): The independent samples have the same central tendency.

H1(alternate hypothesis): At least one independent sample will not exhibit the same central tendency.

A Kruskal-Wallis test examined differences in mean ranks among professional groups on a Likert-scale statements/strategies. The results (Table 2) indicated significant differences between the two groups of construction professionals, H (4) = 12.511a, (P = 0.14); hence, the null hypothesis was rejected (P = 0.05). Post hoc comparisons with Bonferroni correction revealed a significant difference between General Managers (88.25) and subcontractors (42.10) (P = 0.04). No significant differences were found among the Project Managers (57.47), Construction Managers (61.42), and Site Managers (51.48). These results provide crucial insights into enhancing productivity in NZ residential construction.

4.5. Thematic analysis of open-ended questions responses

In addition to structured questions at the outset of the survey, participants were allowed to propose suggestions for improvement through open-ended enquiries. The inductive Thematic analysis revealed 26 themes with various subthemes, generating unexpected insights from the three open-ended questions. The analysis had six recurring themes: LCM, Adequate Supervision, Skilled Workers, Culture, Collaboration, and Procurement Methods, as discussed below.

4.5.1. Question1-analysis of project level productivity improvement strategies NZ residential sector

The analysis of Question One reveals 12 themes (Table 3), with 92 participants responding to project-level strategies for enhancing construction productivity. The top five themes were LCM (1), productivity training and education (2), quality management (3), stakeholder collaboration, adequate supervision and collaboration (4), and incentivisation schemes and skilled workers (5). LCM, a delivery process using lean methods to maximise stakeholder value and minimise waste, is considered the most effective project-level strategy, accounting for 22 % of the responses and includes ten subthemes (Table 3). Additionally, 49 respondents believed Lean Construction could be used individually or in combination to boost productivity. Productivity training and education were identified by 15 % of the participants, with 29 advocating specific training and 14 recommending stakeholder education. This study highlights the need for greater strategic emphasis on quality management, although agreement on its role in improving productivity is limited. The participants confirmed that a collaborative project environment could enhance productivity, with 28 respondents supporting improved stakeholder supervision. Other themes included incentivisation schemes and skilled workers (8 %), technology adoption (6 %), procurement methods, culture and communication (3 %), and comprehensive design (2 %).

4.5.2. Question 2- analysis of quality management strategies to improve NZ residential construction

Eight themes emerged from analysing the second open-ended question, with 82 participants discussing quality management strategies to improve residential construction productivity (Table 4). The five most common themes are Lean Construction (29 %), focusing on maximising customer value and minimising waste, with sub-themes like quality management checklists, inspections, audits, stakeholder collaboration, and continuous improvement; Plan Do Check Act (26 %) for continuous process improvement; ISO9000 standards (19 %) for quality and productivity enhancement; CONQA Quality Assurance System (QAS) (7 %) for organisational quality assurance; and inspection test plan (ITP) checklists (6 %) for productivity improvement. Other themes, including Project Management Software, Kaizen, and Total Quality Management, received less attention (13 % combined), likely due to participants' limited understanding of their benefits.

4.5.3. Question 3 –analysis of organisation strategies used to improve NZ residential productivity

The analysis of question three reveals 13 themes (Table 5), with 87 participants responding. The five most prevalent strategies for improving construction productivity were Lean Construction (1), collaboration (2), quality management (3), communication (4), and adequate supervision (5). Lean Construction was utilised by 22 % (48) of participants. Inspections and audits are the least-utilised lean strategies. Enhancing collaboration, primarily through contractor workflow coordination meetings, was reported by 14 % (38) of the participants as an effective strategy. One-third (35) employed QA tools, such as quality management checklists and audits. Notably, 10 % (26) reported that their organisations lack productivity improvement strategies. Less frequently mentioned strategies include adequate trade supervision (7 %) (19) and employing skilled workers (6 %, (17), fostering an

Table 4
Sample group demographics in this study.

Age Groups (Years)	Frequency (Percent)	Professions	Frequency (Percent)	Industry Experience (Residential)	Frequency (Percent)	Highest level of Education	Frequency (Percent)
20–29	25 (23.5 %)	General Manager	18 (16.9 %)	2–5 years	30 (28.3 %)	Certificate	39 (36.8 %)
30–39	21 (19.6 %)	Construction Manager	20 (18.8 %.)	6–9 years	33 (31.1 %)	Degree	25 (23.6 %)
40–49	30 (28 %)	Project Manager	21 (19.8 %)	10 + years	43 (40.6 %)	Diploma	38 (35.8 %)
50–59	12 (12 %)	Site Manager	22 (21 %)			Postgraduate	2 (1.9 %)
60 (+)	18 (16.9 %)	Subcontractor	25 (23.5 %)			Other	2 (1.9 %)
Total	(N) 106 (100 %)		(N) 106 (100 %)		(N) 106 (100 %)	Total	(N) 106 (100 %)

organisational culture (4 %, (12), training, project management software, incentive schemes (3 %, (9), procurement methods (2 %, (6), and adequate design, the least effective strategy (1 %).

4.5.4. Key findings summary

This study assessed the impact of quality management strategies on New Zealand's residential construction productivity. Results revealed a consensus among participants on the effectiveness of Lean construction and ISO9000 in enhancing quality and productivity. However, only 20 % of respondents considered ISO9000 standards the best strategy despite recognising their productivity potential. Enhancing local effectiveness requires a better understanding of quality management principles, governmental support, and modern industry leadership. This is further confirmed by the Kruskal-Wallis test in this study, suggesting differences between general managers' and subcontractors' views regarding productivity improvement strategies. Bridging these gaps through education, targeted application, and regulatory support can boost quality management's impact on productivity.

5. Discussion and recommendations

The Mixed Methods approach addresses this research aim. Fourteen strategies to enhance New Zealand residential construction productivity were grouped into two Likert scales: Quality management systems and construction productivity, with corresponding subthemes. Mean value indicators and percentages reflect respondent choices, confirming the participants' agreement levels. The thematic analysis (Tables 5-7) examines three open-ended questions on productivity improvement strategies and quality management systems. The qualitative results support the quantitative findings, enhancing the study's validity and reliability. This methodological approach instils confidence in the accuracy and relevance of the research. The distribution of themes and strategies underscores that improving productivity is a collaborative effort involving multiple stakeholders [42] and is not confined to any particular construction stage.

Strategies to enhance construction productivity are presented at the legislative, industrial, organisational, and project levels.

This study agrees with international research that productivity is a vital performance indicator in the construction industry and requires effective measurement [148,149]. The authors argue that traditional productivity measurement methods are crucial but often time-consuming, labour-intensive, and error-prone [149]. Aligning with the findings of this study, it may confirm a lack of productivity measurement in the local context.

According to recent research, influential organisational culture significantly impacts productivity in the residential construction sector [12,13,150]. The importance is highlighted in the Vietnamese construction sector, where research [151] affirms that organisational culture is crucial for employee productivity in the construction industry. However, participants contradict international studies [12,13,150] and disagree that organisational culture can improve construction productivity, highlighting the disconnect between quality management principles and their more comprehensive benefits.

Respondents have diverse views on the benefits of integrating stakeholder workflow. At the same time, global studies highlight the critical role of workflow collaboration in boosting construction productivity [95,96]. The Nigerian housing sector and Latin American social housing detail the effects of collaborative workflow, improving project performance and productivity, with a 17.24 % productivity increase and a reduction of up to 50 % in construction timeframes, highlighting the clear benefits to the New Zealand residential sector [95,96].

Research [152] highlights the importance of quality management in residential construction's design and procurement phases. While participants disagree about its impact on improving productivity, international studies [152,153] confirm that effective quality management in these stages is crucial for project success, affecting both time and cost. This underscores the gap between local quality management practices and their broader implications, indicating industry-wide training and education needs.

Results confirmed industry support for a programme certifying and training construction professionals to boost productivity, aligning with research linking high-quality vocational training to socioeconomic mobility and regional development [11]. Multiple studies [154,155,156] noted significant improvements in performance from targeted training initiatives, demonstrating their efficacy in enhancing residential productivity. However, programmes are less effective in addressing skilled shortages among an ageing workforce [154], a current local sector issue. This highlights the benefit of specific and targeted training initiatives for the regional sector.

Training initiatives could be implemented through a comprehensive productivity strategy involving legislative collaboration. For instance, this study finds that legislation could enhance New Zealand's residential construction productivity and concurs with empirical research suggesting that optimising regulatory measures supports improved productivity [157,158,159]. However, some researchers [157,158] observe that while specific regulations aim to improve project quality and productivity, they can also present challenges such as time constraints, bureaucratic processes, and increased human resource requirements.

Empirical studies discuss the positive association between strategic leadership and achieving desired cultural attributes within construction organisations. However, participants disagree that productivity can be enhanced through a strategic organisational policy. Conversely, research from Singapore supports productivity as a strategic management policy in construction organisations [160]. Studies indicate that leadership is reflected through organisational culture and can significantly impact productivity in the residential construction sector [12,13] confirming the benefits to the New Zealand industry.

However, New Zealand residential construction professionals

Table 5
Respondent Strategies for Improving New Zealand Residential Construction Productivity.

Q1. Project level strategies to improve construction productivity			
ID#	**Theme**	**Responses**	**Percentages**
1	Incentivisation schemes	24 Participants confirmed that monetary incentivisation schemes (contractor bonuses and higher levels of renumeration) could be used as a strategy for trades and employees to help improve project level productivity.	8 %
2	Adequate Design	7 Participants confirmed that a Buildable design (coordinated and complete) combined with improved use of BIM modelling could be used to improving project level productivity.	**2 %**
3	Communication	9 Participants confirmed that effective communication between all stakeholders could be used as a strategy for improving project level productivity.	**3 %**
4	Collaboration	30 Participants confirmed that a sharing information in a more collaborative project environment at might help improve project level productivity.	**10 %**
5	Culture	9 Participants confirmed that organisational culture in particular employee motivational schemes could be used as a strategy to improve project level productivity.	**3 %**
6	Procurement Methods	9 Participants highlighted that procurement methods such as Early Contractor Involvement (ECI) might be used strategically to help improve project level productivity.	**3 %**
7	Productivity Training and Education	29 Participants confirmed that specific training to improve productivity could be used as a strategy to improve project level productivity. 14 Participants confirmed that providing education to stakeholders on methods for improving productivity could provide strategic benefit used to improve project level productivity.	**15 %**
8	Quality management	30 Participants confirmed that quality management could be used as a strategy for improving productivity at project level	**12 %**
9	Adequate Supervision	28 Participants confirmed that improving supervision of trade workers could be used as a strategy to improve productivity at the project level	**10 %**
10	Lean Construction Methods	49 Participants confirmed that Lean Construction Methods (process improvement, minimising defects, improved leadership, continuous improvement, hold points, Last planner and third party inspections and audits, improved scheduling) could work as a strategy for improving project level productivity. • 6 Participants confirmed that alternate construction methods like offsite construction and prefabricated components could be used strategically to improve productivity at the project level.	**22 %**
11	Technology	11 Participants confirmed that using more technology as a strategy (project management software. automation and robotics) can create a safer and more efficient construction environment for all stakeholders contributing towards improved productivity.	**4 %**
12	Skilled workers	23 Participants confirmed that strategies around the use of skilled workers as human capital could be used for improving productivity at the project level.	**8 %**

N(92) participants answered.

prioritise timely and budgeted project completion over quality, reflecting an industry culture that may undermine confidence in quality management's efficacy [44]. This research aligns with recent international literature [20,57,161,162] highlighting the residential sector's struggle to balance productivity and quality linked to this prevalent culture. The Brazilian construction sector [162] suggests that incorporating quality as a core element in productivity efforts is essential for sustainable progress in residential construction. However, other studies [161,163] argue that enhancing productivity does not necessarily compromise quality.

The Kruskal Wallis test (Table 2) further supports the absence of a quality culture by highlighting the differences in perspectives between General Managers and Subcontractors. The observed variations in the central tendencies imply a lack of effective leadership by General Managers in New Zealand residential construction companies. This is crucial for successfully implementing a quality management system and cultivating a "quality culture." The divergent views on quality management reveal a disconnect between management's idealised conception of quality management and productivity ("work as imagined") and the practical realities experienced by subcontractors ("work as done") in this research.

The findings indicate that quality management in New Zealand's residential construction sector is predominantly reactive, aligning with international research highlighting this approach [36,52]. Similar experiences are observed in the Spanish [164] and Malaysian construction sectors. Despite the increased use of quality management control systems, significant deficiencies persist, resulting in end-user claims and complaints, suggesting that quality control remains reactive. Regulatory decoupling is a common issue, reflecting inconsistent commitment to quality management [76] where problems are identified post-construction rather than prevented during the building process, thus reducing productivity.

This study confirms over half of the participants believed that quality management systems, such as ISO9000, could enhance productivity. This aligns with research [10,25,165] from the Philippines, India, and Sri Lankan construction sectors, which assert that quality management systems lower costs, boost productivity, and enhance market share, improving project outcomes, customer satisfaction, and efficiency. However, conflicting views highlight that participants disagree that a quality management system improves time and cost efficiency, possibly due to a lack of understanding of the purpose and intent of quality management systems. In contrast, research shows the global use of quality management strategies like Total Quality Management, ISO900o, Lean Construction, and Plan Do Check Act can enhance construction time, cost, and quality [20,57].

Many respondents view QMS implementation as costly, likely because of the prevalence of micro companies in the New Zealand industry [42], which may also contribute to the high annual cost of poor quality [45,166]. However, participants don't view cost as a barrier to implementing quality management systems. This aligns with international studies that agree that although quality management systems

Table 6
Quality Management Strategies for Improving New Zealand Residential Construction Productivity.

Q2. Quality management strategies for improving construction productivity			
ID#	**Theme**	**Responses**	**Percentages**
1	Lean Construction Methods	14 Participants confirmed that using Lean Construction Methods as an organizational strategy to manage quality might improve construction productivity. • According to 10 participants, implementing continuous improvement throughout organizational processes as a measure of quality assurance could be used strategically to enhance construction productivity. • 22 Participants confirmed that using checklists to manage quality assurance (QAS) as an organizational strategy could improve construction productivity.	29 %
2	Plan Do Check Act	41 Participants confirmed that using Plan Do Check Act as an organizational strategy to manage quality assurance might enhance construction productivity.	26 %
3	CONQA	11 Participants confirmed that using an industry known Quality Assurance System (QAS) such as CONQA as an organizational strategy might improve construction productivity.	7 %
4	Total Quality Management	According to 4 participants, using management philosophies like Total Quality Management as an organizational strategy might enhance construction productivity.	3 %
5	Kaizen	According to 8 participants, using management philosophies like Kaizen as an organizational strategy might improve construction productivity.	5 %
6	Inspection Test Plan (ITP) Checklists.	According to 9 participants, implementing ITP checklists as an organizational strategy towards quality assurance might improve construction productivity.	6 %
7	ISO9000	28 Participants confirmed that using ISO9000 standards for Quality management (QMS) as an organizational strategy might improve construction productivity.	19 %
8	Technology −PM Software	8 Participants confirmed that using quality assurance checklists within Project management software (Procore and Aconex) as an organizational strategy could enhance construction productivity.	5 %

N(82) participants answered.

implementation incurs high initial costs, long-term benefits like reduced rework, increased efficiency, client satisfaction, and profitability often surpass these costs [42,45]. This emphasises the importance of raising awareness about quality management's strategic value and implies that significant governance and change are required.

Thematic analysis identified 12 practical strategies for enhancing residential construction productivity in New Zealand (Table 1l), with Lean Construction, productivity training and education, collaboration, supervision, and quality management as the top strategies. Some of these strategies align with quantitative findings, such as the need for an industry-wide scheme to certify and train construction professionals [11] and the importance of quality management [75,76]. Unexpectedly,

Table 7
Strategies Organizations Use for Improving New Zealand Residential Construction Productivity.

Q3. Strategies organizations use to improve construction productivity			
ID#	**Theme**	**Responses**	**Percentages**
1	Adequate Supervision	19 Participants confirmed that adequate supervision of trade workers is a strategy used to improve project level productivity.	7 %
2	Collaboration	38 Participants confirmed that workflow coordination meetings is a strategy used to help improve project level productivity.	14 %
3	Communication	32 Participants confirmed that effective communication (meetings and checklists) is used a strategy used among stakeholders to improve project level productivity.	12 %
4	Quality Management	According to 35 participants quality assurance tool such as quality management checklists and quality management Audits can be used as a strategy for improving productivity at the project level.	13 %
5	Skilled workers	17 Participants confirmed that strategies in human capital like using skilled and experienced workers are strategically effective in improving productivity at the project level.	6 %
6	Training	According to 9 participants, staff and contractor Training can be used as a strategy to improving productivity at the project level.	3 %
7	Culture	12 participants confirm that organizational culture can have a positive effect on productivity and can be used as a strategy to improve productivity at the project level.	4 %
8	Adequate Design	2 participants highlight the use of Design factors like Building Information Modelling (BIM) helps improve constructability producing a more buildable design and can have a positive effect on productivity at the project level.	1 %
9	Incentivisation schemes	According to 3 participants, incentivising staff and contractors can be a successful strategy for improving productivity at the project level.	3 %
10	Lean Construction Methods	According to 48 participants used lean construction tools to strategically improve productivity at the project level. Of this 48 responses; • 10 participants focus on minimising defects and reworks. • 18 participants highlight continuous improvement. • 13 participants identified using hold points • 7 participants used inspections and Audits • 12 participants highlight improvements in programming to encompass more detail can be used to improve productivity at the project level	22 %
11	No strategies	26 participants confirm they don't use any strategies to improve their productivity.	10 %
12	Project Management Software	According to 7 participants using production checklists within project management software helps improve productivity at the project level	3 %

(*continued on next page*)

Table 7 (*continued*)

Q3. Strategies organizations use to improve construction productivity			
ID#	**Theme**	**Responses**	**Percentages**
13	Procurement Methods	6 participants confirm Procurement methods (preferred suppliers, ECI and adequate pay for contractors,) can be used strategically to improve project level productivity.	2 %

N(87) participants answered.

participants viewed incentivisation schemes, culture, communication, procurement methods, technology, and skilled workers as less critical.

Thirteen productivity improvement strategies were identified, with the five most prominent being Lean Construction, quality management, improved collaboration, and communication. Empirical research supports that a collaborative culture enhances performance [167]. Participants agreed that workflow coordination meetings at the project level are vital for improving performance. Notably, 10 % reported their organisations lacked productivity improvement strategies, indicating room for enhancement. Project management software, procurement methods, incentivisation schemes, adequate design, training, culture, supervision, and skilled workers were deemed less significant.

Five primary quality management strategies were identified: Lean Construction Plan Do Check Act, ISO9000, CONQA, and Inspection Test Plans. Plan Do Check Act or Lean Construction can be used with ISO9000, relevant at organisational and government levels, as an effective combined quality management solution. However, ISO9000 is the only comprehensive quality management system among the suggested strategies, aligning with quantitative findings and previous research highlighting its effectiveness [79,80,81,82]. Other strategies focus narrowly on QC and QA, indicating a need for a better understanding of the use of quality management systems at the industry level.

A critical analysis revealed commonalities across construction sector levels. Quality management, a global industry standard (ISO90000) since 1987, consistently links quality and productivity [53,168,169] and is part of a comprehensive model for sustainably improving New Zealand construction productivity [42]. Governments in Australia, Hong Kong, and Singapore have used quality management to guide industry quality objectives since the 1980 s [160,170,171,172]. At the organisational level, quality management as a strategic policy ensures consistent quality and product delivery and enhances construction performance [170,173,174], directly driving improved productivity at the project level [26].

Quality management must transition from a reactive tool to a strategic function to improve New Zealand's residential construction performance [21]. Tailored training enhances supervision and training but remains limited. Adopting the ISO9000 standard fosters a "quality culture" [83] integrating communication, collaboration, supervision, and training strategies across the supply chain and government, ensuring a comprehensive approach to boost productivity. The documented benefits of quality management at legislative, [160,170,171,172] organisational [173,174] and project levels [28,175] are rarely considered collectively for enhancing productivity. About 10 % of respondents indicated their organisations lacked productivity improvement strategies, and less than half agreed their quality management systems met quality objectives, highlighting the need for change. A broader strategy can significantly enhance organisational and industry performance, benefiting society [3]. New Zealand policymakers and industry leaders should consider broad-scale ISO9000 implementation as practised in other nations [176]. The study proposes a five-step approach (authors own works):

1. Industry research: Evaluate current quality management practices.
2. Stakeholder Engagement: Raise awareness and form a task force of industry experts, government representatives, and academic researchers.
3. Implementation Framework: Develop training, pilot programmes, gradual rollout, and certification support.
4. Monitoring and Evaluation: Establish metrics for quality and productivity, with continuous evaluation and adjustment.
5. Change Management: Address SME challenges with grants, subsidies, transparent communication, staff involvement, and success stories.

Sector-specific resources, such as digital handbooks, can mitigate barriers to ISO9000 implementation by translating standards into actionable steps for construction firms [29]. Long-term success requires leadership commitment and government support [72,73,74,75,76], and collaborative networks in other countries have facilitated the exchange of best practices [72]. Regular follow-ups, government assistance, and an industry-wide quality management network are advantageous.

This study highlights the need for an affordable, accessible, and certifiable industry-wide training program to improve productivity. The Singaporean Building Construction Authority (BCA) Academy [177] could be an adaptable model. The BCA promotes construction quality and productivity through incentives and legislation that foster innovation [178]. BCA Academy provides ongoing education and training, including fundamental courses [178,179,180,181] like "Basic Concept in Construction Productivity Enhancement (BCCPE)" for small and medium enterprises and advanced programs such as the Advanced Certificate in Construction Productivity (ACCP) and Specialist Diplomas in Construction Productivity. These courses cover productivity improvement, quality enhancement, management skills, value engineering, technological advancements, and new construction technologies. The "Certified Construction Productivity Professional (BCA CCPP) Scheme" recognised experts leading productivity initiatives [182]. and "The Good Industry Practices" course disseminates best practices via digital books [183].

The BCA's incentivisation strategies and legislative support with accessible training options merit consideration for the local sector.

These training options highlight the importance of quality management and its link to productivity. They showcase government-led programs suitable for New Zealand's construction industry within a broader productivity enhancement framework. Combined with the ISO9000 standards, these programs can be adapted locally. They offer structures to enhance industry knowledge on quality and productivity, potentially raising New Zealand's productivity standards and industry culture.

Research confirms [45] that improving the quality of residential construction in New Zealand boosts productivity and performance, leading to new growth and consumption opportunities. This study shows that enhanced quality results in an annual economic increase of $112 million in residential construction output, a 1 % yearly rise in capital investment, and a 1.3 % wage increase. Additionally, the downstream effects suggest a NZD 2.5 billion increase in New Zealand GDP as production costs decrease, providing households an extra NZD 1.4 million for goods and services, thereby raising living standards and societal well-being [45].

Increased construction productivity in New Zealand has a societal impact beyond economic benefits. Reducing project timelines is crucial for addressing housing shortages, increasing housing availability, and enabling more families to access affordable homes sooner, potentially decreasing homelessness. Green building practices that enhance productivity promote sustainable methods, such as using eco-friendly materials, renewable energy, and energy-efficient designs, thus improving housing standards. The construction sector could address housing deficits by incorporating lean, environmentally sustainable practices.

Moreover, efficient resource and waste management are essential for environmental sustainability. These advancements support ecological goals and enhance residents' quality of life, fostering a healthier, more

stable, and equitable society. As New Zealand faces housing and sustainability challenges, improving construction productivity is vital for achieving these societal objectives.

Love et al. [184] noted that rework constitutes 10–30 % of total construction costs. Thus, implementing quality management practices can reduce defects, lower end-user costs, and boost productivity. For example, a housing firm constructing ten homes annually at NZD 1 million could save NZD 100,000 per home by reducing rework costs from 20 % to 10 %. Achieving 10 % greater efficiency lowers end-user costs, enhances housing affordability, and improves living standards. Additionally, improved efficiency allows the firm to produce one extra home yearly with the same resources, increasing productivity. Enhanced quality management leads to more efficient production at lower costs, demonstrating the strategy's societal benefits.

These points advocate for a multifaceted approach to improving construction productivity, addressing the industry's evolving demands. The findings highlight the need for increased awareness of the strategic value of QMS and substantial governance and change. The discussion identifies practical strategies to enhance New Zealand residential construction productivity. Emphasising quality management as the primary strategy is vital for future improvements in New Zealand's construction sector. Although strategies can be applied individually or collectively, a multidimensional approach is most comprehensive.

6. Implication to theory and practice

Research indicates that, despite various strategies and governmental initiatives, New Zealand's construction productivity has stagnated for over thirty years [33]. This study's findings are significant for New Zealand's residential sector. The six primary strategic themes identified were quality management, training and education, collaboration, Lean construction, and adequate supervision. These themes provide insights from legislative, organisational, and project levels for improving residential construction productivity. A key implication is the association between quality management and enhanced productivity, emphasising the strategic importance of quality management investments and potential industry-wide improvements by policymakers.

The findings also highlight the crucial role of worker training in improving productivity. Accessible and specific training initiatives that enhance productivity skills and knowledge can significantly improve worker productivity and project outcomes. These strategies are essential for improving New Zealand residential construction productivity, benefiting all stakeholders.

This research investigates New Zealand's residential construction industry, providing insights that could inform global theories. Contextual studies are vital for adapting universal theories to specific sectors, highlighting the importance of this research. Grounded in the Theory of Constraints (TOC), it enhances theoretical development and integrates quality management and productivity, bridging both with detailed empirical knowledge. The TOC posits that a few fundamental limitations hinder an organisation's progress [185,186,187]. The construction industry integrates quality management with TOC to improve quality and productivity by systematically addressing these limitations [185]. TOC aligns with quality management's focus on identifying and eliminating bottlenecks: workflow delays compromising quality and productivity.

However, TOC requires further integration with frameworks like Total Quality Management, Six Sigma, and ISO9001 to address the complexities of New Zealand's construction industry [185,187]. Such integration could fully realise TOC's potential, advancing academic research and practical innovations. The relationship between TOC and quality management systems (Total Quality Management, Six Sigma, ISO9000) is evident when addressing bottlenecks [185,186] highlighting that quality assurance protocols identify limitations to facilitate corrective actions that improve the system rather than address isolated issues [185].

This study highlights the importance of targeted quality enhancements to boost productivity, proposing that quality management should be a primary strategy within a comprehensive productivity plan. Combining quality management frameworks (ISO9000, Lean construction, and Total Quality Management) with TOC ensures continuous improvement, aligning quality management practices with productivity objectives. Managing constraints effectively prevents defects, reduces rework, improves processes, and fosters continuous improvement, leading to efficient construction practices and better project outcomes. Integrating quality management with TOC offers a robust theoretical framework for addressing challenges in the modern local construction industry [185].

This study challenges the notion that alternative productivity improvement methods are preferable to quality management. It presents a multidimensional analysis within a robust theoretical framework, showing how quality management strategies can drive productivity improvement and enrich existing theories with empirical insights.

Through empirical evidence, this research contributes to the existing body of knowledge on quality management and productivity in New Zealand's residential construction sector.

7. Conclusion

There is yet a universal solution to improving productivity in the construction industry. This study employs a novel methodology to explore the perspectives of the New Zealand residential construction industry on productivity enhancement. It offers unique findings and strategies for policymakers and professionals and guides future research.

The Theory of Constraints underpins this research, providing a theoretical lens that enhances its academic rigour and relevance. The findings bridge the gap between quality management and productivity theory, demonstrating the effectiveness of quality management in improving productivity in New Zealand's residential sector. Thus, they advance academic understanding.

This study categorises productivity enhancement strategies into six main themes: training, productivity assessment, quality management, industry culture, communication, and stakeholder collaboration. These themes can be applied individually or collectively at legislative, industry, organisational, and project levels to improve industry performance. Secondary themes like adequate design, technology, procurement methods, incentive schemes, and human capital are important but less critical.

Findings suggest that New Zealand's residential sector's persistent underperformance indicates deep-rooted issues that require substantial time to address. Enhancing productivity requires a multidimensional approach, including improved quality management, regulatory changes, better industry cultures, and training. Given the sector's socioeconomic significance and the link between quality and productivity, the authors advocate for regulatory changes that prioritise these aspects nationally.

Key findings highlight the need for an industry training scheme to boost construction productivity, aligning with Singaporean research, where government-led training focuses on quality management and productivity improvement. This approach could benefit New Zealand's broader construction sector, including commercial and industrial sectors. The results stress the importance of enhancing workforce skills, improving quality management, addressing an ageing workforce, prioritising labour-reducing innovations, and advocating supportive government policies. Immediate impacts are possible through lean construction, supported by this study as a strategy to optimise processes, reduce waste, and shorten schedules, leading to better performance and sustainable practices.

However, Lean construction methods do not explicitly aim to improve quality.

The study advocates integrating Lean construction with ISO9000 standards to boost productivity. Findings highlight the importance of quality management as a global benchmark for raising industry standards. Participants agree on the efficacy of ISO9000 standards in

enhancing New Zealand residential construction productivity. ISO9000 implementation can foster a quality-oriented culture, improving communication, collaboration, and training, thereby increasing productivity. The framework's flexibility allows for integrating other organisational policies to improve business performance, presenting a comprehensive strategy for productivity enhancement and sustainable performance gains. The study suggests that focused quality management drives productivity, recommending a strategic reorientation within the sector.

However, current quality management efficacy in New Zealand's residential sector requires improvement through better understanding, government support, and enhanced leadership. The study notes differing views on productivity improvement strategies between general managers and subcontractors. Addressing these differences through education, targeted application, regulatory support, and training can strengthen quality management's impact on construction productivity.

Quality management emerges as a holistic and universal strategy for enhancing productivity in New Zealand's residential construction sector at organisational, industry, and policy levels. Coordinated efforts are needed to improve the quality and productivity of residential buildings in New Zealand. Implementing these findings requires significant shifts in stakeholders' mindsets, attitudes, and behaviours.

Future research could investigate the application of these approaches in other construction areas and the impact of digital technologies, such as further integrating BIM with lean construction techniques, within New Zealand's building industry.

8. Limitations/implications

This study highlights quality management's role in improving residential construction productivity in New Zealand but faces limitations. These include reliance on self-reported data from a small sample (N = 106) of construction professionals, possibly causing non-response bias and limiting generalisability. While demonstrating quality management's effectiveness, broader samples, human behaviour, and organisational psychology should be considered for a comprehensive understanding. Future data analysis methods should balance strategy complexities that affect productivity. Future research should use larger samples and longitudinal studies to validate these findings practically. Although valuable, caution is needed when generalising results to the broader construction industry.

The researchers acknowledge potential limitations in the study's methodology, particularly the objectivity of findings due to self-reported data. The involvement of industry professionals may introduce bias, compromising research validity. These professionals might present their practices overly favourably, overstating positive results or downplaying negatives. Additionally, cognitive biases like optimism bias could affect participants' evaluations of their experiences or the industry's overall state. Triangulating self-reported data with objective measures, observational studies, or administrative data could enhance future study validity. The authors also note that a small sample size can reduce the reliability and generalisability of findings. Fewer participants increase the likelihood that the sample does not represent the heterogeneous nature of the construction industry's diversity, raising the margin of error and resulting in unstable estimates. Consequently, findings from a limited sample may not apply to a larger, more representative population in future studies. Despite these limitations, this study lays a foundation for future research.

CRediT authorship contribution statement

Mark Kirby: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Funmilayo Ebun Rotimi:** Supervision. **Nicola Naismith:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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