Standardised innovation management systems: Modelling the antecedents of certification and maintenance benefits

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Abstract

The literature lacks a comprehensive model examining the performance impact of certifying and maintaining standardised innovation management systems (SIMS), or clarifying the advantages of standardisation. This study addresses that gap by analysing the key determinants of the benefits associated with SIMS certification and maintenance. Drawing on the literature and data collected from 103 Portuguese organisations holding certified SIMS, a partial least squares structural equation model (PLS-SEM) is developed that encompasses two critical stages of the certification life cycle: initial certification and maintenance. The results reveal that SIMS maintenance significantly influences maintenance benefits, underscoring its pivotal role in sustaining organisational performance. Certification motivations strongly affect certification benefits but do not directly enhance maintenance benefits, exerting only a moderate indirect impact mediated by maintenance motivations. Maintenance motivations, critical success factors (CSFs), and certification benefits emerge as the principal predictors of maintenance benefits. Although certification barriers do not directly influence performance, they exert a persistent indirect negative effect, highlighting the importance of effectively managing maintenance CSFs. In addition, two subsets of organisations display contrasting relationships between barriers and benefits (one negative and the other positive) reflecting differences in strategic alignment with SIMS and in the perceived importance of resource availability. This study is the first to examine the antecedents of SIMS maintenance benefits and to propose an empirical model explaining their determinants; it is also the first to integrate two main stages of the SIMS certification life cycle within a single framework. The findings contribute to the SIMS, ISO 9001, and ISO 14001 literature, where such frameworks are currently lacking, and offer valuable theoretical and practical insights for optimising the certification and maintenance of management systems so as to enhance organisational performance. Notably, the study demonstrates that the impact of barriers on performance is nuanced, and reveals the importance of nurturing maintenance motivations, given that initial certification motivations lose their direct effect over time. Overall, the study clarifies not only that standardisation is beneficial, but also how these benefits can be effectively realised and sustained.

Keywords: certification barriers, certification maintenance, certification motivations, critical success factors, ISO 56001, ISO 9001, NP 4457, performance, standardised innovation management systems, UNE 166002.

1. Introduction

The maintenance of standardised innovation management systems (SIMS) has been recommended to ensure the sustained competitiveness and long-term performance of organisations (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024). SIMS are grounded in national standards such as the British BS 7000-1:1989, the Spanish UNE 166602:2006, and the Portuguese NP 4457:2007 (Mir et al., 2016). The International Organisation for Standardisation (ISO) has also developed guidelines for innovation management systems (ISO, 2019) and, more recently, published the first international standard for SIMS, ISO 56001, in September 2024 (ISO, 2024). Certification based on these standards supports the systematic management of innovation processes (Mir et al., 2016; Martínez-Costa et al., 2019), which are critical to organisational competitiveness and sustainability (Mir et al., 2016; Garechana et al., 2017; Khan *et al*., 2021).

However, achieving and maintaining these benefits requires more than initial implementation. Sustained innovation outcomes may depend on the continuous and effective maintenance of certified systems (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024). To ensure that SIMS continue to foster innovation, organisations must regularly review, update, and improve their systems (Wahid and Corner, 2009; Castka, 2018; ISO, 2024). Management systems maintenance refers to the set of activities required to keep the systems in effective operational condition after implementation (Basir and Davies, 2018; Castka, 2018). These activities include assessment, performance measurement, internal auditing, corrective action, and continuous improvement (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024). They often demand significant resources and managerial effort, and organisations may encounter various constraints during implementation and maintenance (Santos *et al*., 2019). Consequently, the effectiveness of SIMS likely depends on a range of antecedents – such as certification motivations, barriers, and maintenance-related critical success factors (CSFs) – that influence their outcomes. Yet, empirical research on these antecedents remains virtually non-existent, despite their fundamental importance for sustaining SIMS benefits over time.

Research on SIMS remains relatively scarce and fragmented (Espín *et al*., 2023; Kihlander et al., 2024), reflecting the recent emergence of innovation management standardisation as a 21st-century phenomenon. Existing studies have mainly focused on the development and refinement of innovation management standards (Hyland and Karlsson, 2021), the implementation of SIMS (Pellicer et al., 2012; Yepes et al., 2016), the integration of multiple management standards (González et al., 2012), or specific antecedents such as certification motivations, barriers, and success factors (Caetano, 2017; Santos et al., 2019). Others have investigated the benefits of SIMS implementation (Martínez-Costa et al., 2019; Mir et al., 2016, 2022), and their relationship with green innovation and sustainability (Khan et al., 2021). Additionally, some scholars have explored the broader and multifaceted theoretical interconnections between standardisation and innovation (Wright et al., 2012; Blind *et al*., 2022).

Most of this research has been conceptual (*e.g*., Khan *et al*., 2021) or case-based (*e.g*., Wright et al., 2012), with only a few descriptive surveys (*e.g*., Santos *et al*., 2019), including the authors' previous work (Saboya *et al*., 2025). To date, just three quantitative studies have developed empirical models linking SIMS and firm performance, all of them using structural equation modelling (SEM). The first (Mir *et al*., 2016) identifies SIMS as an enabler of business performance through the mediation of innovation capability and innovation performance. The second (Martínez-Costa *et al*., 2019) finds that SIMS positively affect four types of innovation (organisational, marketing, product and process) and overall performance. The third (Espín et al., 2023) confirms SIMS' positive impact on performance via incremental and radical product innovation. Similarly, Mir *et al*. (2022), employing fuzzy set qualitative analysis, show that standardisation significantly contributes to innovation performance (not firm performance).

Despite these advances, the literature has yet to reach a clear consensus on the relationship between standardisation and innovation, a topic that remains both conceptually and empirically contested. The purpose of innovation management standards is to enhance organisations' innovation capabilities by creating a shared terminology and structuring innovation processes, to improve efficiency (Mir et al., 2016). However, a long-standing debate persists regarding the potential (in)compatibility between innovation, creativity, and standardisation (Wright et al., 2012; Garechana et al., 2017). Critics contend that innovation, by nature, resists standardisation, arguing that formalisation constrains creativity and acts as an impediment to innovation (Wright et al., 2012; Alfaro, 2019; Tidd and Bessant, 2021:578). Innovation challenges established routines and drives organisational transformation, whereas standardisation promotes efficiency, consistency, and uniformity of behaviour (Birkinshaw et al., 2008; Wright et al., 2012; Tidd and Bessant, 2021:578). Consequently, standardisation can lead to rigidity and resistance to change (Mir et al., 2016; Tidd and Bessant, 2021:578), reducing the flexibility deemed essential for creativity and innovation (Mir and Casadesús, 2011).

In contrast, other scholars maintain that standardisation can complement and even strengthen innovation (Wright et al., 2012). From this perspective, innovation can be more effectively managed through structured and standardised management systems (Mir et al., 2016), and standardisation may be indispensable for addressing the complexity and uncertainty inherent in innovation processes (Alfaro, 2019). Reconciling these opposing views, SIMS appear to offer a pragmatic balance between the need for structure and the flexibility required for creativity (Mir and Casadesús, 2011; Wright et al., 2012). Indeed, empirical evidence suggests that organisations adopting SIMS achieve substantial and significant performance benefits (Mir et al., 2016; Garechana et al., 2017; Saboya *et al*., 2025).

Nevertheless, even though SIMS have been shown to produce positive outcomes (Mir et al., 2016; Martínez-Costa et al., 2019; Espín et al., 2023), previous models have not examined the antecedents of certification and maintenance benefits. Most studies treat SIMS as an independent variable, overlooking factors such as certification barriers, motivations, and the critical success factors associated with system maintenance. As a result, the literature lacks a general model explaining how the antecedents of SIMS certification and maintenance contribute to sustained performance. In general, the SIMS literature has not yet examined maintenance-related issues. Moreover, even in the well-established ISO 9001 and ISO 14001 research streams, limited attention has been paid to maintenance (Balzarova and Castka, 2008; Cândido, 2024), and no comparable theoretical frameworks exist for identifying the determinants of maintenance benefits (Camango and Cândido, 2023).

To address this gap, the present study aims to develop a model of the antecedents of SIMS certification and maintenance that integrates several mediating variables leading to certification and maintenance benefits. Specifically, the research examines the relationships between certification variables (motivations, barriers, benefits), and maintenance variables (motivations, critical factors, and benefits). By doing so, it captures two key stages of the SIMS life cycle – certification and maintenance (Cândido, 2024) – and explains how these processes jointly determine the benefits obtained from continued SIMS implementation.

While innovation is often perceived as inherently flexible and resistant to formalisation (Mir and Casadesús, 2011; Mir et al., 2016; Garechana *et al*., 2017; Tidd and Bessant, 2021:165) the feasibility and benefits of standardising innovation management remain underexplored in the literature (Mir et al., 2016; Alfaro, 2019; Saboya *et al*., 2025). This study contributes to that debate by situating standardised innovation management systems within the broader innovation management discourse (e.g., Birkinshaw *et al*., 2008; Wright *et al*., 2012; Alfaro, 2019) and empirically analysing their certification and maintenance. By developing and testing a structural model linking motivations, barriers, critical success factors, and benefits, the study demonstrates that SIMS can be effectively implemented and maintained, producing enduring innovation and performance advantages. The findings clarify not only that the standardisation of innovation processes is feasible but also how such standardisation can yield measurable benefits through the alignment of internal motivations, management practices, and strategic orientations with innovation outcomes.

Finally, to test this model, the study draws on data from Portuguese organisations certified under the national standard NP 4457:2007 (IPQ, 2007a, 2007b), building upon and extending a previous investigation by the same authors (Saboya et al., 2025). That earlier study provided the first descriptive empirical evidence of the SIMS certification life cycle – documenting motivations, barriers, benefits, and decertification in Portugal – but did not examine the relationships among these variables, nor propose an explanatory model of their determinants. The present study addresses this limitation by developing and testing a structural model using a final, enlarged dataset and partial least squares structural equation modelling (PLS-SEM). Portugal provides a suitable empirical context due to its pioneering role in the development of NP 4457:2007 – one of the earliest national innovation management certification standards – and the substantial experience with certification, maintenance, and decertification, accumulated by Portuguese organisations, thus offering a mature and instructive setting for examining the SIMS life cycle. Moreover, the Portuguese NP 4457:2007 is conceptually aligned with ISO 56002 and the newly published ISO 56001, ensuring the international relevance of the findings. Accordingly, insights from this context extend beyond national boundaries, contributing to the refinement and broader applicability of innovation management standards.

In doing so, the research not only advances understanding of SIMS certification and maintenance but also enriches the ISO 9001 and ISO 14001 literature, which similarly lacks an integrated framework linking motivations, barriers, and long-term benefits across the certification life cycle (Camango and Cândido, 2023). Above all, the study contributes to the ongoing discussion on the compatibility between standardisation and innovation (e.g., Wright *et al*., 2012; Garechana *et al*., 2017; Alfaro, 2019; Saboya *et al*., 2025), demonstrating that structured approaches can coexist with creativity and adaptability.

2. Literature review and hypotheses

2.1. Standardised innovation management systems

Innovation is a crucial factor for organisational competitiveness (Tidd and Bessant, 2021). Firms can use innovation as a strategic tool to gain advantage and succeed in both local and global markets (Schumpeter, 1934). Consequently, innovation management has become a core component of organisational strategy (Badrinas and Vilà, 2015; Micheli et al., 2020; Tidd and Bessant, 2021:3,10,116). It aims to structure and align organisational areas, resources, processes, and practices to create a systematic, continuous, and manageable innovation process (Hollins, 1999; Correa et al., 2007; Karlsson and Magnusson, 2019; Gimenez-Fernandez et al., 2021; Tidd and Bessant, 2021:vi,45,166); thereby fostering innovation and value creation (Hollins, 1999; Tidd and Bessant, 2021:vi,166).

A standardised innovation management system pursues the same objective by enabling the integration of novel concepts and enhancing an organisation's ability to acquire, develop, and apply new knowledge (Correa et al., 2007; Karlsson and Magnusson, 2019).

The Portuguese NP 4457:2007 is one such standard, based on Kline's (1985) chain-linked innovation model (AENOR, 2006; IPQ, 2007a). It assists organisations in defining, implementing, maintaining, and improving their innovation policies and applies to firms of all sizes, complexity degrees, and sectors. The standard comprises four main sections: management responsibilities, planning, implementation and operations, and assessment and improvement. It shares similarities with the ISO 9001 and ISO 14001 and can be certified by an independent third party (IPQ, 2007b).

Certification follows a life cycle comprising three stages: adoption and implementation, maintenance, and recertification or decertification (Castka, 2018; Camango and Cândido, 2023; Cândido, 2024; Delfino et al., 2024). The first stage involves planning and implementing the changes required to comply with the standard's requirements, culminating in the award of certification, which is typically valid for three years. During the subsequent maintenance stage, the organisation must ensure that the management system remains in good operating order. Independent annual audits are conducted to verify that maintenance activities are being properly executed, ensuring the systems' continuous improvement and continued compliance with the standard. Finally, the organisation must then decide whether to apply for a new certification (recertification) or opt for decertification. If the organisation achieves recertification, another three-year maintenance period ensues.

2.2. Certification motivations, maintenance motivations, and benefits

Key motivations for SIMS certification include fostering a culture of innovation and enhancing innovation capability (Mir et al., 2016; Correa et al., 2007), as well as improving business performance (Badrinas and Vilà, 2015, Santos et al., 2019). Additional motivations are presented in Table S1 of the Supplementary Materials (included at the end of this file). The expected benefits of certification closely correspond to these motivations – strengthening innovation culture, improving innovation capability (Yepes et al. 2016; Garechana et al., 2017; Santos et al., 2019), and achieving competitiveness and performance gains (Pellicer et al., 2012; Khan et al., 2021). This correspondence between motivations and benefits (Saboya *et al*., 2025) suggests a relationship between the two variables. Indeed, certification motivations represent the underlying reasons why organisations decide to certify (Santos *et al*., 2019) and, as such, should logically constitute antecedents of the benefits derived from certification.

According to social psychology, motivations are key determinants of human behaviour; the stronger the motivation, the stronger the resulting behaviour and benefits (Ajzen, 1985, 1991, 2020; Sultan *et al*., 2020). Although this reasoning was originally developed to explain individual behaviour, it can be extended to the organisational level on the following grounds. First, organisations are social systems governed by social and psychological mechanisms, and are therefore not immune to the motivational dynamics that social psychology describes (e.g., Jimmieson et al., 2008; Zheng et al., 2018). Second, organisational behaviour can be understood either as the aggregation of individual intentions and motivations converging into collective action and outcomes (e.g., Jimmieson *et al*., 2008; Hemsworth *et al*., 2026), or as the expression of a single dominant decision-maker whose motivation shapes the behaviour of the entire organisation (Christodoulaki et al., 2024). In either case, motivational constructs at the individual level find a meaningful analogue at the organisational level. Third, previous research has already undertaken analogous adaptations of social psychology frameworks to explain organisational-level behaviour, demonstrating that group dynamics, shared norms, and shared motivations can produce specific organisational behaviours and outcomes (Jimmieson et al., 2008; Zheng et al., 2018; Christodoulaki et al., 2024; Hemsworth et al., 2026). We acknowledge that this adaptation introduces boundary conditions, since organisational behaviour is also shaped by structural, institutional, and political factors that may moderate the motivations-outcomes relationship. Nonetheless, given that certification decisions in SIMS are typically driven by managerial intent and organisational commitment, this adaptation is considered theoretically defensible.

Building on this reasoning, the present study proposes that stronger organisational motivations to certify should lead to greater certification benefits (H1). Higher motivation is likely to translate into increased resource allocation and stronger management commitment, ultimately enhancing performance. Although this relationship remains unexplored in the SIMS literature, empirical evidence from ISO 9001 research supports a positive link between motivations and benefits (Ferreira and Cândido, 2021; Camango and Cândido, 2023).

Prior ISO 9001 research suggests that initial certification motivations evolve over time and are progressively replaced by other forms of motivation (Prajogo, 2008; Kakouris and Sfakianaki, 2019; Cândido, 2024) – namely, maintenance motivations. Gagné and Deci (2005) recognised that individuals' motivations evolve over time in organisations, and studied the conditions under which extrinsic (external) motivations can be converted into intrinsic (internal) motivations. Research on ISO certification also indicates that some motivations, particularly internal motivations such as the desire to improve processes and foster innovation and culture, tend to increase over time (Prajogo, 2008; Kakouris and Sfakianaki, 2019; Cândido, 2024). Within the SIMS literature, Saboya et al. (2025) found that external motivations tend to fade over time, being progressively overcome by internal motivations, further suggesting that initial certification motivations are not static but evolve in nature and orientation. Consequently, it is reasonable to expect that initial certification motivations help to shape subsequent maintenance motivations and, by extension, to be positively related to them (H2), as organisations seek to sustain the benefits initially achieved and continue improving the system.

Maintenance motivations are diverse (see Table S1 in Supplementary Materials) and can be identified in the SIMS standards (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024) or adapted from the ISO 9001 literature (e.g., Wahid et al., 2011; Castka, 2018). They include the requirements established by the standard to maintain the system, as well as the perceived threat of decertification in cases of inadequate maintenance. When organisations fail to maintain compliance with the standard, they risk losing both certification and its associated benefits. Conversely, the performance improvements promoted by certification (AENOR, 2006; IPQ, 2007b; Mir *et al*., 2016; Martínez-Costa *et al*., 2019; Espín et al., 2023; ISO, 2024) can themselves reinforce the motivation to retain certification.

This relationship between realised benefits and the motivation to sustain certification draws support from theoretical and empirical perspectives. From an empirical standpoint, Ong et al. (2015) found that the perceived usefulness of ISO 9001 drives the behavioural intention to continue using the standard. From a theoretical standpoint, social psychology consistently holds that positive performance outcomes strengthen subsequent motivation. Wood and Bandura (1989) demonstrate that past performance successes strengthen self-efficacy and motivational processes within organisations. Gagné and Deci (2005) argue that performance outcomes, such as job satisfaction and rewards, contribute to enhanced motivation. Ajzen (2015, 2020) further contends that the outcomes of past behaviours can feed back into the actor's belief system, shaping future motivations and behaviours. Therefore, it is reasonable to expect that greater perceived certification benefits will lead to higher motivation to maintain certification (H3).

Although the ISO 9001 and ISO 14001 literatures are more mature than SIMS research, they have only examined the relationship between certification motivations and certification benefits (see Camango and Cândido, 2023). Previous SIMS studies have not empirically investigated any of the three relationships examined in this section. However, the literature suggests that certification motivations are likely to be positively related to both maintenance motivations and certification benefits, and that certification benefits may, in turn, positively influence motivations to maintain certification.

Accordingly, the following hypotheses are proposed:

H1: Certification motivations positively affect certification benefits.

H2: Certification motivations positively affect maintenance motivations.

H3: Certification benefits positively affect maintenance motivations.

2.3. Certification barriers and certification benefits

The broader innovation management literature indicates that several barriers can be detrimental to implementing innovation and change management systems (Alshwayat et al., 2023). Organisations can also face barriers during the implementation and certification of SIMS (see Table S1 in the Supplementary Materials). These barriers are similar and include internal and external difficulties, such as insufficient resources (time, money, personnel, equipment; Caetano, 2017; Martínez-Costa et al., 2019), bureaucracy (Martínez-Costa et al., 2019), insufficient qualifications (Caetano, 2017), lack of management commitment, personnel resistance to change (Santos et al., 2019), and financial and legal barriers (Lopes et al., 2012; Santos et al., 2019). These barriers can make it difficult for the organisation to implement any strategic initiative in general (Cândido and Santos, 2019) and to certify the SIMS. It is therefore reasonable to expect that the higher the barriers, the higher the difficulty in implementing the standard. Consequently, the higher the barriers faced during certification, the lower the benefits extracted from it, as organisations will need to make additional efforts to overcome them.

Previous research in social psychology suggests that barriers are key determinants of human (lack of) behaviour, and the stronger the barriers, the less robust the human behaviour and its associated benefits (Ajzen, 1985, 1991, 2020; Li *et al*., 2023; Koskela and Karppinen, 2024). However, this relationship between certification barriers and benefits has not been addressed in the SIMS literature. To the best of the authors' knowledge, only a couple of studies have considered this relationship in the ISO 9001 literature, but with contrasting results. One study found a significant relationship between certification barriers and ISO 9001 benefits (Sun *et al*., 2019) while another study found the relationship was not statistically significant (Cândido and Ferreira, 2023). Researching this relationship in the SIMS context adds to the literature because innovation management may be less amenable to standardisation than quality management, SIMS are more recent and less institutionalised, and the uncertainty intrinsic to innovation processes makes barriers harder to anticipate and overcome, rendering the barrier-benefit relationship potentially more consequential in this context.

Given the lack of research on this relationship, the contrasting results of the existing ISO 9001 studies, and the reasonable expectation that organisations facing certification obstacles should obtain suboptimal benefits, the fourth research hypothesis is thus:

H4: Certification barriers negatively affect certification benefits.

2.4. Maintenance motivations, critical success factors, and benefits

Learning and adaptation (i.e., the maintenance) of innovation management systems are essential for successful and sustained innovation (Teece, 2018; Tidd and Bessant, 2021:571-594). Likewise, the maintenance of SIMS certification and the realisation of its benefits require continual commitment following the system's implementation. Top management's ongoing commitment, together with a strong innovation culture, continuous improvement, and teamwork, are critical success factors (CSFs) for the maintenance of SIMS (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024). Similarly, as suggested by research on ISO 9001, clear communication of responsibilities, availability of resources, training, recognition, and rewards (Table S2 in the Supplementary Materials) are also relevant CSFs (Wahid and Corner, 2009; Wahid et al., 2011). Firms that exhibit these CSFs are likely to maintain the certificate and its benefits (AENOR, 2006; IPQ, 2007b; ISO, 2024). These CSFs are also fundamental for the creation and maintenance of successful non-certified innovation management systems (Tidd and Bessant, 2021:100,164-214,571-594). Thus, it is reasonable to hypothesise that the stronger the CSFs in an organisation, the higher its certification maintenance benefits.

However, the success of SIMS maintenance can also depend on the organisation's motivations to maintain it. Motivation plays a key role in building and sustaining a culture of creativity and innovation (Tidd and Bessant, 2021:42). As already noted, maintenance motivations include some that are similar to certification motivations and others that are new. Motivations change over time (Prajogo, 2008; Kakouris and Sfakianaki, 2019; Cândido, 2024) because the circumstances of companies implementing a SIMS are different from those of an organisation maintaining it. Thus, maintenance motivations include the desire to maintain continuous improvement, to reinforce the innovation culture, to maintain the certification benefits, and to avoid losing the certification (Table S2 in the Supplementary Materials). To avoid losing the certification, the motivations must also be aligned with the standard's requirements, including regularly conducting maintenance activities and periodically assessing the organisational performance (AENOR, 2006; IPQ, 2007b; ISO, 2019, 2024). In accordance, it is reasonable to expect that maintenance motivations should be positively related to maintenance performance. Previous research also suggests that motivations are key determinants of behaviour, and the stronger the motivations, the more robust the behaviour and its associated benefits (Ajzen, 1985, 1991, 2020; Sultan *et al*., 2020). Thus, the higher the SIMS maintenance motivations, the higher the maintenance benefits. A comparable relationship can be found in the innovation management literature, where the need to maintain learning feedback loops (maintenance motivation) to strengthen innovation capability and sustain competitiveness (benefits) is emphasised (Teece, 2018; Tidd and Bessant, 2021:571-594).

These relationships between maintenance CSFs, motivations, and benefits have not been researched yet in the SIMS literature, nor in the ISO 9001 literature. In the case of ISO 9001, however, two studies address the relationship between maintenance motivations and maintenance activities (Ong *et al*., 2015; Castka, 2018), suggesting that stronger motivations are associated with more intense maintenance activities. Furthermore, three studies investigate the relationship between maintenance activities and organisational performance (Arauz and Suzuki, 2004; Lo and Chang, 2007; Pan *et al*., 2009), indicating that greater maintenance intensity enhances performance outcomes. Taken together, these findings suggest that stronger maintenance motivations should lead to higher maintenance-related benefits. Nevertheless, there are no empirical studies on the direct relationship between these variables (see Camango and Cândido, 2023). In other words, current research has yet to consider the effect of the antecedent – maintenance motivations – on maintenance performance.

In short, given the lack of research on these relationships, the standard's requirements, and the reasonable expectations about the relationships that can be derived from current literature, it is justifiable to formulate the following hypotheses:

H5: Maintenance motivations positively affect maintenance benefits.

H6: Maintenance CSFs positively affect maintenance benefits.

2.5. Certification benefits and maintenance benefits

Maintenance benefits may differ from certification benefits, depending on maintenance motivations and critical success factors, as already suggested. However, the level of the previous certification benefits can also help to explain the level of benefits attained in the maintenance stage. Previous research on the determinants of human behaviour has shown that perceived benefits of the behaviour can have a positive impact on that behaviour (Ajzen, 1991; Shmueli, 2021). Thus, the higher the level of certification benefits, the higher the level of maintenance benefits to expect. Under desirable circumstances, maintenance benefits should be higher than certification benefits because, with the passing of time, organisations can improve the SIMS, and the benefits should also improve.

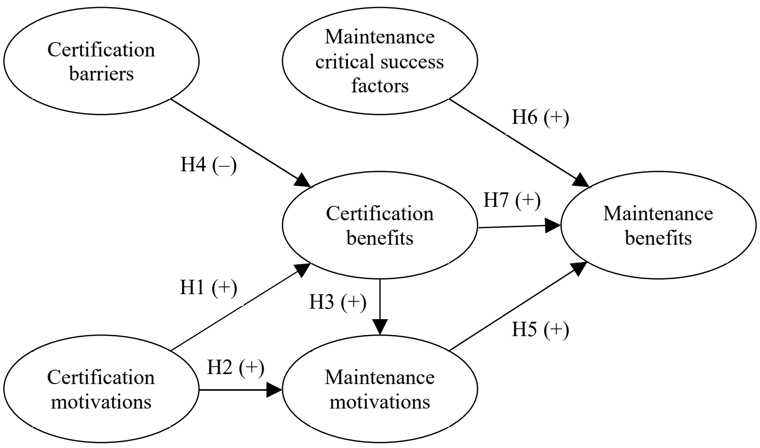
Unfortunately, there is no research on the relationship between these variables, not even in the ISO 9001 literature. The available research on ISO 9001 suggests that firms that maintain the certification attain higher benefits (Lo and Chang, 2007), that maintenance activities influence firms' performance (Arauz and Suzuki, 2004; Pan *et al*., 2009), that certification benefits can be sustained during the maintenance stage (Prajogo, 2008), and that firms implementing more complex maintenance activities should achieve higher performance (Castka, 2018). All these results suggest that certification benefits can be maintained or increased in the maintenance stage of certification. However, the ISO 9001 literature is not consensual in this regard, and the persistence of the benefits over the period of certification validity is still debatable (Cândido *et al*., 2016). In fact, some ISO 9001 longitudinal studies show persistence in benefits over the years (*e.g*., Siougle *et al*. 2019) while others show a null, negative or decreasing effect (*e.g*., Lindlbauer *et al*., 2016; Cândido *et al*., 2021). This lack of agreement is also visible in studies addressing the performance impact of certification over longer periods of time, beyond the three-year period of the initial certification (e.g., Aba et al., 2016; Cândido et al., 2016; Hernandez-Vivanco et al., 2019; Siougle et al., 2019; Liu et al., 2021; Siougle and Dimelis, 2021).

Given the lack of research on this relationship in the field of SIMS and the controversial results in the field of ISO 9001, this research posits that the benefits from SIMS certification, related, for instance, to better innovation capability, gains in competitiveness, and firm performance (Table S2 in the Supplementary Materials), are sustained in the maintenance phase. Thus, the last hypothesis:

H7: Certification benefits positively affect maintenance benefits.

Having defined the research hypotheses, Figure 1 summarises the proposed research model.

Figure 1. Research model



3. Research methodology

3.1. Population, sample, and statistical power

The target population for this study consists of Portuguese companies certified according to the innovation management standard NP 4457:2007. As of December 31, 2021, this population includes 169 organisations with valid certifications (IPAC, 2021).

The sample size estimation is based on achieving a statistical power of 80%, a significance level of 5%, and a minimum significant path coefficient of 0.21 to 0.30. According to Hair et al. (2022:27), the minimum sample size required under these conditions is 69.

Upon completion of the statistical analyses, a post hoc analysis was performed using

SmartPLS (Ringle *et al*., 2022) to confirm the adequacy of the sample size. The post hoc analysis indicates that the minimum sample size required is 93. Since the actual study sample size is n=103, which is greater than both the initial estimate and the post hoc analysis requirement, the statistical power of this study exceeds 80% or the significance level is better than 5%.

3.2. Data collection method

The study is based on self-reported data, which is common in management research, particularly when variables such as motivation, barriers and perceived benefits are involved. To avoid response bias, the researchers identified the person responsible for innovation management in each organisation and sent an invitation to participate in the study directly to this individual. The invitations were sent by email to the designated recipients of all organisations in the population. The invitations contained information on the purpose of the study, identification of the researchers, and a link to the online questionnaire. The data collection started on April 27, 2022, and ended on July 11, 2022. During this period, five of the questionnaire recipients informed the researchers that they had recently lost the certificate and were excluded from the study. During data collection, the researchers received a total of 103 completed and valid responses, which corresponds to a valid response rate of 60.9%.

3.3. Research instrument and variable measurement

The research instrument is a questionnaire designed by the researchers, containing two main groups of queries. The first group contains six questions, one per latent variable in the research model, based on previous investigations on SIMS. These queries and the corresponding measurement items are detailed in tables S1 and S2, in the Supplementary Materials, with the five-point rating scale adopted for all items and the corresponding sources for each item. The second group of questions includes queries about the respondents and the certified organisations where they work. All questions were originally developed in Portuguese, and no translation or backtranslation was required.

The researchers took ex-ante precautions in developing the research instrument to avoid bias. These precautions address the writing of the questionnaire, the information provided to the respondents, the assurances given by the researchers, and a pre-test to fine-tune the instrument (Podsakoff et al., 2003; Chang et al., 2010). Firstly, the questionnaire was written with care to ensure clarity, neutrality, and conciseness. Secondly, respondents were informed that there is no right or wrong answer to any of the questions and that answers should be as close as possible to their true beliefs. Thirdly, respondents were assured that their responses would be treated and published only in an aggregate manner, and no individual information would be made available to anyone outside the research team. Lastly, a pre-test was conducted with a small number of respondents (6) to identify any necessary adjustments, which were minimal.

3.4. Data analysis

This research builds upon a previous study conducted by the same authors (Saboya *et al*., 2025). That earlier work, based on a slightly smaller preliminary dataset comprising 94 observations, provided a detailed description of the research variables using descriptive statistics and univariate non-parametric tests. The present study differs in scope, objectives and methodological sophistication. It employs a final, slightly larger dataset (n=103), focuses on a subset of the research variables, applies advanced analytical techniques (PLS-SEM), and examines the relationships among these variables, which were not explored previously (hypotheses H1 to H7). Although there is partial overlap with the earlier dataset, as this study adds nine new observations, the two papers pursue distinct aims and utilise different methodologies.

The data analysis in this study comprises the following stages:

(1) normality, randomness and bias tests,

(2) analyses of the PLS-SEM measurement and structural models;

(3) exploratory analysis, and

(4) correlation analysis.

Additional analyses are presented in the Supplementary Materials, including:

(5) control variables' analysis,

(6) endogeneity assessment,

(7) heterogeneity analysis, and

(8) sensitivity analysis comparing PLS-SEM results between the two samples (n=94 vs. n=103) (see Sections S1-S4 in the Supplementary Materials).

3.5. PLS-SEM

There are two methods for developing structural equation models (SEM), such as the one in the research model (Figure 1). One method is covariance-based (CB-SEM), and the other is partial least squares-based (PLS-SEM). Both methods combine regression analysis with some form of factor or composite analysis, which allows them to deal with non-observable latent variables. The researchers adopted the latter method (PLS-SEM) because it can be used to create and test theories, as well as to make predictions on the variables of interest (Hair *et al*., 2019, 2022). The method can also be used for exploratory research (Hair *et al*., 2022:2,28).

This study combines the explanatory, predictive, and exploratory approaches. It is primarily an explanatory and predictive analysis because its goal is to introduce the first model in the literature that explains and predicts SIMS maintenance benefits. This model incorporates variables such as implementation barriers, maintenance motivations, and critical success factors of certification maintenance. Concurrently, the study includes an exploratory analysis to investigate the antecedents that influence SIMS certification maintenance benefits. PLS-SEM was chosen not only for enabling these analyses but also due to its demonstrated ability to provide greater statistical power with smaller samples and its flexibility in not making assumptions about data distributions (Hair et al., 2022). All calculations were conducted using SmartPLS, SPSS, and Excel.

4. Results

4.1. Sample description

Table 1 shows the main descriptive statistics for the constructs in the research model. According to the table, certification motivations are moderate to strong (mean=3.773), as are maintenance critical success factors (mean=3.752), maintenance benefits (mean=3.736), and maintenance motivations (mean=3.509). Certification benefits have a slightly lower and moderate mean value (mean=3.435), whereas certification barriers are below the midpoint of the rating scale and can be considered weak to moderate (mean=2.585). These findings suggest that the surveyed organisations have generally experienced a reasonable level of success in implementing and maintaining SIMS certification.

Additional information on the main sample characteristics and the descriptive statistics for each measurement item can be found in tables S3 and S4 of the Supplementary Materials.

4.2. Data distribution, randomness, and bias tests

The results of the Cramér-Von Mises tests (Table S4 in the Supplementary Materials) suggest that the 34 measurement items in the model follow a non-normal data distribution (p=0.000). Non-normal distribution of the data, however, does not constitute a problem because

PLS-SEM does not make distributional assumptions (Hair et al., 2022:65). Non-normality can only be problematic when it is extreme, but that is not the case here since the absolute values of Skewness and Kurtosis are all clearly below the 2.0 threshold (Hair *et al.*, 2022:66).

Table 1. Measurement model statistics, correlation matrix, HTMT, VIF, R^2 and Q^2

Latent variable	Mean	SD	CR	AVE	CMOT	CBAR	CBEN	MMOT	MCSF	MBEN	R^2	Q^2
Certification motivations (CMOT)	3.773	0.742	0.914	0.653	**0.808**		1.097	2.554				
Certification barriers (CBAR)	2.585	0.821	0.884	0.551	-0.297 (0.307)	**0.742**	1.097					
Certification benefits (CBEN)	3.435	0.836	0.936	0.794	0.780 (0.844)	-0.258 (0.264)	**0.891**	2.554		2.432	0.609	0.471
Maintenance motivations (MMOT)	3.509	0.794	0.838	0.598	0.715 (0.813)	-0.216 (0.227)	0.728 (0.820)	**0.773**		2.280	0.586	0.336
Maintenance critical success factors (MCSF)	3.752	0.709	0.879	0.659	0.583 (0.650)	-0.292 (0.311)	0.628 (0.693)	0.595 (0.699)	**0.812**	1.768		
Maintenance benefits (MBEN)	3.736	0.728	0.882	0.665	0.709 (0.789)	-0.264 (0.295)	0.770 (0.842)	0.730 (0.848)	0.730 (0.823)	**0.816**	0.723	0.460

Notes: Above the diagonal are the variance inflation factors (VIF), on the main diagonal, in bold, are the square roots of average variance extracted ($AVE^{½}$), below the diagonal are the correlations, and in parentheses are the heterotrait-monotrait ratios (HTMT). n=103.

The Wald-Wolfowitz runs-test for sample data randomness suggests that 33 (97.1%) out of the 34 items considered in the research (tables S1, S2 and S4 in the Supplementary Materials) exhibit random behaviour. The p-values for the 33 variables are greater than the test significance level of 0.05, which supports the retention of the data randomness hypotheses.

The Mann-Whitney U, Kolmogorov-Smirnov, and Jonckheere-Terpstra tests were conducted to compare the subsample of the first 52 respondents (50.5%) with that of the later 51 respondents (49.5%). Thirty-three of the 34 items (97.1%) exhibit a p-value that is higher than 0.05, indicating that the null hypotheses of identical subsamples' data distributions should be retained. Accordingly, the two subsamples can be considered as coming from the same population, which means that there is no evidence of non-response bias (Wagner and Kemmerling, 2010).

These two tests are particularly relevant because the questionnaire was distributed to the entire population rather than to a randomly selected sample, which could otherwise raise concerns about data randomness or non-response bias. The test results collectively suggest that these potential issues are not present and that the data are suitable for further analysis.

To mitigate potential common-method bias, the researchers adopted several ex-ante preventive measures (see Sections 3.2 and 3.3), following Chang et al. (2010). Additionally, two ex-post statistical tests were performed. First, the Harman single-factor test showed that the single factor extracted from the exploratory factor analysis explains 40.4% of the total variance in the 34 measurement items – below the 50% threshold recommended (Podsakoff et al., 2003) – thus suggesting the absence of common-method bias. Second, the variance inflation factors (VIF)-based test proposed by Kock (2015) further suggests that the ex-ante procedures were effective in avoiding common-method bias.

4.3. Measurement model

Three measurement items with outer loadings below 0.4 were omitted from the measurement model, to ensure indicator reliability. Some of the remaining items, with outer loadings in the range of 0.4 and 0.7, were equally omitted to improve indicator reliability, as well as the internal consistency and convergent validity (Hair *et al.*, 2022:118). In accordance, the average variance extracted (AVE) of all constructs are above the minimum of 0.5 (Table 1), which demonstrates the convergent validity of the measurement model (Hair *et al.*, 2022).

The composite reliability (CR) indicators (Cronbach alpha, rho a, and rho c) of all constructs are also above the corresponding threshold of 0.7, which suggests that the measurement model further exhibits internal consistency reliability (Hair *et al*., 2022). Table 1 shows the CR as calculated by rho a.

Lastly, the discriminant validity is cumulatively demonstrated by: (1) the outer loadings surpassing the corresponding cross-loadings, (2) the square root of the average variance extracted ($AVE^{½}$) of the latent variables surpassing the correlations with other latent variables (Table 1), and (3) the heterotrait-monotrait ratios (HTMT) showing values below the 0.90 maximum and even below the stricter 0.85 threshold (Table 1; Hair *et al*., 2022).

Together, these analyses suggest that the 34 items in the measurement model (Table S4 in the Supplementary Materials) exhibit indicator reliability, internal consistency reliability, convergent validity, and discriminant validity (Hair *et al*., 2022).

4.4. Structural model

Analysis of the structural model involves an assessment of (1) multicollinearity issues, using the variance inflation factor (VIF) values, (2) explanatory power, using the coefficient of determination (R^2), (3) predictive power of the model, by means of Q^2, root mean square error (RMSE) and mean absolute error (MAE), (4) magnitude of the total effects, (5) significance and relevance of the direct effects (structural coefficients), and (6) signs of the estimated structural coefficients.

Firstly, all variance inflation factors (VIF) values (see Table 1) are lower than the stricter limit of 3.0 (Hair *et al*., 2022:191). These VIF values suggest that there are no collinearity issues in the estimated structural model.

Secondly, the coefficient of determination R^2 can be considered high for all exogenous variables. The certification benefits R^2 is 0.609, the maintenance motivations R^2 is 0.586, and the maintenance benefits R^2 is 0.723 (Table 1). Lower values than these are common in management research (e.g., 0.10, Hair et al 2022:195). Thus, the R^2 values suggest that the structural model explains the behaviour of the main variables of interest and, as such, has (high) explanatory power.

Thirdly, the Q^2 values (Table 1) and the Q^2 predict values (Table S5 in the Supplementary Materials) are all above zero. In addition, the PLS-SEM root mean square error (RMSE) and the mean absolute error (MAE) values, obtained with the PLS predict procedure, considering k=3 folds and r=10 repetitions, are all lower than the corresponding maximum threshold limits (LM RMSE and LR MAE, Table S5). Such results indicate that the structural model exhibits high out-of-the-sample predictive power (Hair *et al*., 2022:196).

Fourthly, there are two strong total effects, one between certification motivations and certification benefits (0.772, Table 2), and another between certification motivations and maintenance motivations (0.712). There are also five moderate total effects: (1) between certification benefits and maintenance benefits (0.475), (2) between certification motivations and maintenance benefits (0.464), (3) between certification benefits and maintenance motivations (0.434), (4) between maintenance CSFs and maintenance benefits (0.349), and (5) between maintenance motivations and maintenance benefits (0.259). There are also two moderate specific indirect effects, one is the CMOT→CBEN→MMOT (0.335), and the other is the CMOT→CBEN→MBEN (0.280). There are other effects than those in the table, but they are weak (<0.2) or insignificant (p>0.05).

Fifthly, the significance of the path coefficients was assessed with a percentile bootstrap-based test with 10,000 subsamples (Table 3). Results show that all but one of the path coefficients are significant at the 5% level. Only the coefficient associated with Hypothesis H4, relating certification barriers to certification benefits, is not statistically significant.

Table 2. Total effects and indirect effects

Path	Indirect effect	Total effect
Panel A: Effects on certification benefits		
CMOT→CBEN		0.772***
Panel B: Effects on maintenance motivations		
CMOT→MMOT	0.335***	0.712***
CBEN→MMOT		0.434***
Panel C: Effects on maintenance benefits		
CMOT→MBEN	0.464***	0.464***
CBEN→MBEN	0.112**	0.475***
MMOT→MBEN		0.259***
MCSF→MBEN		0.349***
Panel D: Some specific indirect effects		
CMOT→CBEN→MMOT	0.335***	
CMOT→MMOT→MBEN	0.097**	
CMOT→CBEN→MBEN	0.280***	
CMOT→CBEN→MMOT→MBEN	0.087**	

Notes: *** Significant at the 1 percent level. ** Significant at the 5 percent level. CBAR, Certification Barriers; CBEN, Certification Benefits; CMOT, Certification Motivations; MBEN, Maintenance Benefits; MCSF, Maintenance Critical Success Factors; MMOT, Maintenance Motivations. Unilateral p-values. n=103.

Lastly, Table 3 shows that the signs of the structural coefficients are all in accordance with the signs of hypotheses H1 to H7. Thus, the analysis of the structural model performed in this study supports all but hypothesis H4.

4.5. Exploratory analysis

Given the lack of research on SIMS certification maintenance, this study includes an exploratory analysis by considering four additional relationships beyond those initially modelled: (1) CMOT→MBEN, (2) CBAR→MBEN, (3) CMOT→CBAR, and (4) CBAR→MCSF (Figure 3). However, results indicate that the first two added relationships are not statistically significant ($p>0.05$). While the last two relationships are significant, they explain only 9.0% of the variance in certification barriers (CBAR) and 9.5% of the variance in maintenance CSF (MCSF). Moreover, incorporating these four new paths into the structural model does not change the magnitude and significance of the primary paths already in the model (H1 to H7). Specifically, the maximum absolute changes observed are 0.059 in coefficient values (Max $|\Delta\text{coefficient}|=0.059$), 0.014 in p-values (Max $|\Delta\text{p-value}|=0.014$), and 0.005 in explained variance (Max $|\Delta R^2|=0.005$). These minimal changes do not change the significance of the main research hypotheses. Therefore, the four additional paths were not considered relevant nor were they included in the final research model.

Table 3. Results for the structural model

	Hypothesis	Expected effect	Path coefficient	Confidence interval 5%	Confidence interval 95%	t statistic	p-values	Decision
H1	CMOT→CBEN	(+)	0.772***	0.675	0.840	15.294	0.000	Supported
H2	CMOT→MMOT	(+)	0.377***	0.178	0.576	3.104	0.001	Supported
H3	CBEN→MMOT	(+)	0.434***	0.211	0.653	3.217	0.001	Supported
H4	CBAR→CBEN	(–)	-0.028 $^{n.s.}$	-0.148	0.044	0.476	0.317	Not Supported
H5	MMOT→MBEN	(+)	0.259***	0.120	0.402	3.024	0.001	Supported
H6	MCSF→MBEN	(+)	0.349***	0.211	0.526	3.654	0.000	Supported
H7	CBEN→MBEN	(+)	0.363***	0.177	0.496	3.714	0.000	Supported

Notes: $^{n.s.}$ Not significant, *** Significant at the 1 percent level. CBAR, Certification Barriers; CBEN, Certification Benefits; CMOT, Certification Motivations; MBEN, Maintenance Benefits; MCSF, Maintenance Critical Success Factors; MMOT, Maintenance Motivations. Unilateral p-values. n=103.

4.6. Correlation analysis for two pairs of subsamples

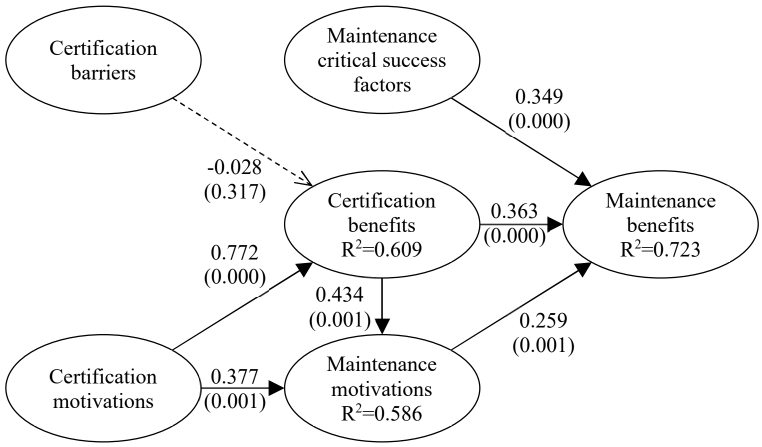
The lack of significant coefficients between certification barriers and certification benefits (H4), as well as between certification barriers and maintenance benefits (Section 4.5), is intriguing. A negative relationship was expected (see H4). To investigate why these relationships did not show a significant negative coefficient, the correlations between the two pairs of variables were calculated for all possible subsamples of the main sample. For this purpose, all research items not included in the measurement model (See Section 4.3 and Table S4 in the Supplementary Materials) were considered for splitting the sample in two halves. For the vast majority of the subsamples, the correlations provided the same sign and similar magnitudes. However, for two pairs of subsamples, the signs of the correlations are different. The two items used to split these samples are a certification barrier (misalignment of the SIMS with strategy, CBAR4), and a critical success factor (contribution of resource availability to the success of the SIMS, MCSF5). Tables 4 and 5 show the results of the corresponding correlations.

Additional analyses are provided in the Supplementary Materials, including the analysis of control variables, the assessment of endogeneity, the examination of heterogeneity, and a sensitivity analysis comparing the PLS-SEM results obtained with the two samples (n=94 vs. n=103).

5. Discussion

Empirical results (Figure 2) show that certification motivations exert a strong, positive, and statistically significant direct effect on certification benefits (0.772, p=0.000), explaining approximately 61% of the variance in this latter variable (R^2=0.609). This provides robust support for hypothesis H1 and suggests that stronger SIMS certification motivations lead to greater certification benefits for organisations. This relationship is theoretically sound since (1) motivations represent the underlying drivers that prompt organisations to pursue certification (Santos *et al*., 2019), and (2) there is a clear alignment between the types of motivations (*e.g*., fostering an innovation culture, enhancing capabilities, improving competitiveness, and boosting firm performance; Correa *et al*., 2007; Mir *et al*., 2016; Santos *et al*., 2019) and the types of benefits that certified firms achieve (*e.g*., improved innovation culture, capability, competitiveness, and firm performance; Yepes *et al*., 2016; Garechana *et al*., 2017; Khan *et al*., 2021). This finding constitutes an original contribution to the SIMS literature, as no prior studies have examined this relationship. However, similar evidence has been reported in the ISO 9001 literature, where Ferreira and Cândido (2021) observed a comparable strong effect, and earlier research found that internal motivations tend to generate internal benefits, whereas external motivations lead to external benefits (e.g., Sampaio et al., 2012; Djofack and Camacho, 2017). The convergence of these findings across different certification frameworks suggests that the link between certification motivations and benefits is consistent and generalisable, extending beyond national standards to include ISO-based systems.

Figure 2. Structural model main results

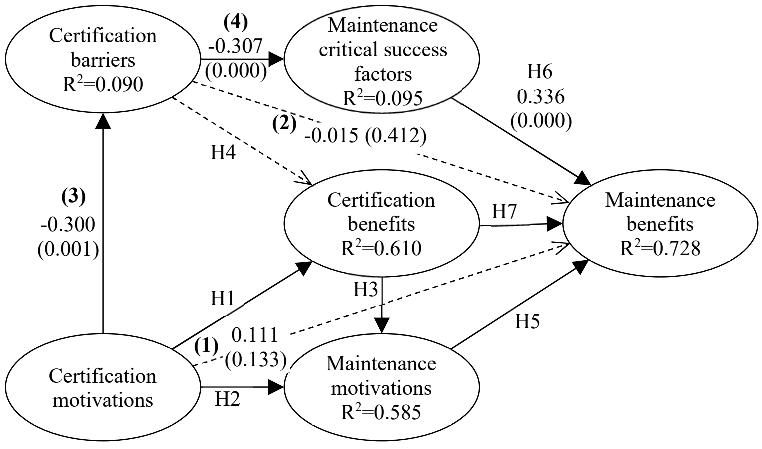


Certification motivations have a moderate, positive, and statistically significant direct impact on maintenance motivations (0.377, p=0.001), lending support to hypothesis H2. This result indicates that certification motivations persist long enough to foster maintenance motivations, which are crucial for the ongoing support and maintenance of SIMS certification. Consequently, certification motivations do not dissipate entirely after certification but instead lay the groundwork for maintenance motivations. The higher the certification motivations, the higher the maintenance motivations. Consistent with this analysis, Table 1 shows that both the averages and standard deviations of certification and maintenance motivations are quite similar (3.773 vs. 3.509 and 0.742 vs. 0.794, respectively). These results, while original even for the ISO 9001 literature, are consistent with previous research suggesting that initial certification motivations change over time and are progressively replaced or complemented (Prajogo, 2008; Kakouris and Sfakianaki, 2019; Cândido, 2024) by maintenance motivations.

Certification benefits have a moderate, positive, and statistically significant direct impact on maintenance motivations (0.434, p=0.001), supporting hypothesis H3. This finding indicates that higher certification benefits achieved during the initial phase of certification lead to stronger motivations to sustain efforts in maintaining the SIMS certification. Companies need to continuously perform maintenance activities (AENOR, 2006; IPQ, 2007b, ISO, 2019, 2024), which they are unlikely to undertake if the benefits of certification do not justify the effort. Therefore, it is important to recognise that the benefits realised from certification significantly stimulate maintenance motivations. This result is consistent with Ong et al. (2015), who found that the perceived usefulness of ISO 9001 drives the behavioural intention to continue using the standard.

This direct effect of certification benefits is also crucial because it contributes to the indirect impact of certification motivations on maintenance motivations. The strong positive impact of certification motivations on benefits (H1: 0.772) combines with the moderate positive effect of benefits on maintenance motivations (H3: 0.434) to generate a moderate indirect effect of certification motivations on maintenance motivations (0.772×0.434=0.335, p=0.001, Table 2, Panel D). This means that certification benefits partially mediate the effect of certification motivations on maintenance motivations. Initial certification motivations thus persist over time and, supported by certification benefits, help build the motivations necessary to maintain the SIMS. When combined with the direct effect of certification motivations (H2: 0.377), this indirect effect results in a strong total effect (0.377+0.335=0.712, p=0.000). These findings make an original contribution to the literature on SIMS, ISO 9001 and ISO 14001, as no previous studies have examined these relationships (Camango and Cândido, 2023).

Figure 3. Paths added for the exploratory analysis



Certification barriers exhibit a weak and non-significant relationship with certification benefits (-0.028, p=0.317), insufficient to support the hypothesised negative relationship (H4).

Although the sign of the structural coefficient is negative, as expected, suggesting that barriers are detrimental to firm performance, the coefficient is very weak and insignificant. The similar relationship between barriers and maintenance benefits was also explored (Section 4.5) and consistently provided negative and insignificant results, indicating no direct effect of barriers on any type of certification benefits. This result is surprising and original for the SIMS literature, given the lack of previous research and the unexpected findings. In the ISO 9001 literature, previous research has found both similar (Cândido and Ferreira, 2023) and contrasting results (Sun *et al*., 2019). Cândido and Ferreira (2023) found no significant relationship between certification barriers and benefits, whereas Sun *et al*. (2019) found a significant negative relationship, similar to the one hypothesised here.

To help clarify the lack of significant relationship between barriers and benefits in this study and the contrasting results in the ISO 9001 literature, correlation and heterogeneity analyses were conducted (sections 4.6 and S3 in the Supplementary Materials). The analyses suggest that for the subsample of companies with a strategy aligned with the SIMS (CBAR4=1 or 2, n=68), the correlation is significant and negative, as predicted by H4, whereas for the group of organisations without a SIMS-aligned strategy (CBAR4=3, 4 or 5, n=35) the correlation is positive but insignificant at the 5% level (Table 4). The difference in correlation signs explains the lack of a significant relationship in the whole sample (Table 3). More importantly, it suggests that certification barriers can have completely different impacts depending on the alignment of the organisation's strategy with its SIMS. With an aligned strategy, the higher the barriers, the lower the benefits. Trusting in their strategic alignment, these organisations may have difficulty overcoming higher certification barriers, negatively impacting their perception of certification benefits. This aligns with hypothesis H4 and with social psychology theory (Ajzen, 1985, 1991, 2020; Li *et al*., 2023; Koskela and Karppinen, 2024). However, organisations with a SIMS-misaligned strategy that face higher barriers obtain higher perceived benefits, a counterintuitive result that requires explanation, because it is at odds with social psychology theory. Perhaps not trusting in their weak strategy alignment, these organisations make a stronger effort to overcome their higher obstacles, obtaining benefits directly proportional to that effort (and the magnitude of the barriers), despite the misalignment of the strategy. This would align with the constraints-as-enablers logic (Hernandez-Vivanco and Bernardo, 2022; Chen and Shen, 2023), whereby higher obstacles trigger intensified effort, more disciplined resource use, creativity, and ultimately higher perceived benefits.

Similarly, the analysis suggests that for the subsample of companies for whom resource availability is an important SIMS maintenance CSF (MCSF5=3, 4 or 5, n=86), the correlation is significant and negative, as predicted by H4. In contrast, for the group of organisations for whom resource availability is not an important maintenance CSF (MCSF5=1 or 2, n=17), the correlation is positive and significant (Table 5). This difference in correlation signs between subsamples also helps explain the lack of a significant relationship in the whole sample. More importantly, it provides further evidence that certification barriers can have completely different impacts on performance depending on the perceived importance of resource availability for the maintenance of SIMS. With the perception that resource availability is an important maintenance CSF, the higher the barriers, the lower the benefits. Perhaps trusting in their resource availability, these organisations (mostly larger companies[2]) struggle to overcome higher certification barriers, negatively impacting their perception of certification benefits,

[2] The correlations between MCSF5 (importance of resource availability) and company employee number (0.293, p=0.003) and between MCSF5 and company business volume (0.252, p=0.010) are both positive and statistically significant. This indicates that larger organisations, which typically have more resources, hold stronger beliefs about the importance of resource availability for the success of SIMS certification. Conversely, smaller organisations, with fewer resources, have weaker beliefs about the importance of resource availability for the success of the SIMS.

which aligns with hypothesis H4 and with social psychology theory (Ajzen, 1985, 1991, 2020; Li *et al*., 2023; Koskela and Karppinen, 2024). However, organisations that perceive resource availability as not an important MCSF and face higher barriers obtain higher perceived benefits. This counterintuitive result may be because, due to insufficient resources, these organisations (mostly smaller companies[1]) make more efficient use of resources when faced with higher obstacles, obtaining benefits directly proportional to that efficiency (and the magnitude of the barriers). This would again align with the constraints-as-enablers logic (Hernandez-Vivanco and Bernardo, 2022; Chen and Shen, 2023), whereby higher obstacles trigger intensified effort, more disciplined resource use, creativity, and ultimately higher perceived benefits.

Table 4. Correlations for the subsamples split with CBAR4

	Organisations with a SIMS-aligned strategy (CBAR4 = 1 or 2, n=68)	Organisations with a SIMS-misaligned strategy (CBAR4 = 3, 4 or 5, n=35)
	Expected sign of correlation according to H4 (-)	Expected sign of correlation according to H4 (-)
Certification barriers (CBAR) correlation with certification benefits (CBEN)	-0.418***	+0.327
Certification barriers (CBAR) correlation with maintenance benefits (MBEN)	-0.403***	+0.422

Notes: Pearson correlations of construct scores. CBAR4 not included in the measurement model (Section 4.3, Table S4). *** Significant at the 1 percent level. Unilateral tests.

Table 5. Correlations for the subsamples split with MCSF5

	Organisations believing that availability of resources does not contribute to the success of the SIMS (MCSF5 = 1 or 2, n=17)	Organisations believing that availability of resources contributes to the success of the SIMS (MCSF5 = 3, 4 or 5, n=86)
	Expected sign of correlation according to H4 (-)	Expected sign of correlation according to H4 (-)
Certification barriers (CBAR) correlation with certification benefits (CBEN)	+0.538***	-0.370***
Certification barriers (CBAR) correlation with maintenance benefits (MBEN)	+0.587***	-0.375***

Notes: Pearson correlations of construct scores. MCSF5 not included in the measurement model (Section 4.3, Table S4). *** Significant at the 1 percent level. Unilateral tests.

The observed correlations in Tables 4 and 5 can be interpreted through a dual-theory perspective. Organisations with strong strategic alignment or abundant resources follow a pattern consistent with social psychology theory: higher barriers are perceived as detrimental because these firms, trusting in their strategy or resources, may expect to overcome obstacles easily, and encountering higher barriers than anticipated reduces their perception of certification benefits. Conversely, organisations with weak alignment or scarce resources exhibit a pattern consistent with constraints-as-enablers logic, whereby higher barriers trigger intensified effort, disciplined resource use, and creative problem-solving, ultimately generating higher perceived benefits despite limited resources or strategic misalignment.

More research is necessary to clarify the relationship between barriers and benefits and how these theories contribute to explaining it. This research, however, has made an original contribution by suggesting that, in the context of SIMS, the relationship between certification barriers and benefits is contingent and can even invert, depending on specific organisational conditions, namely, the degree of strategic alignment with the SIMS and the perceived importance of resource availability for SIMS success. Further research should examine whether this contingency holds across different standards.

Maintenance motivations have a moderate, positive, and statistically significant direct impact on maintenance benefits (0.259, p=0.001), contributing to explain 72.3% of the variance in the latter variable (R^2=0.723) and supporting hypothesis H5. As hypothesised, higher maintenance motivations lead to greater benefits from certification maintenance. Maintaining certification requires continuous effort to keep the SIMS in good operating order (AENOR, 2006; IPQ, 2007b, ISO, 2024), and these efforts are justified because stronger efforts lead to stronger benefits. Compared to the results of the similar hypothesis H1, the empirical support for H5 indicates that organisations need to remain motivated to support maintenance activities to continue reaping benefits. A decline in motivations will lead to a decline in benefits.

Additionally, there is a small but positive and significant indirect effect of initial certification motivations on maintenance benefits, mediated by maintenance motivations (0.097, p=0.023, Table 2, Panel D). This suggests that the impact of initial certification motivations persists over time, contributing to benefits during the maintenance stage. However, this effect is indirect and small, indicating that maintenance benefits depend heavily on other factors, such as maintenance motivations, which must remain high.

This analysis of maintenance motivations and benefits is original for both the SIMS and ISO literature. While two ISO 9001 studies explore the relationship between motivations and maintenance activities (Ong et al., 2015; Castka, 2018), and three studies examine the link between maintenance activities and organisational performance (Arauz and Suzuki, 2004; Lo and Chang, 2007; Pan et al., 2009), no empirical study has yet investigated the direct relationship between maintenance motivations and benefits (see Camango and Cândido, 2023). Thus, this study contributes to the literature by proposing and empirically demonstrating that maintenance motivations are a significant antecedent and predictor of maintenance benefits.

Maintenance critical success factors have a moderate, positive, and statistically significant direct effect on maintenance benefits (0.349, p=0.000), contributing to explain 72.3% of the variance in the latter variable (R^2=0.723), thereby lending support to hypothesis H6. This result empirically supports the claims of SIMS standards such as AENOR (2006), IPQ (2007b), and ISO (2024), which suggest that mastering CSFs – such as management commitment, innovation culture, continuous improvement, and teamwork – is fundamental for achieving higher SIMS certification maintenance benefits. Until now, these claims lacked empirical (quantitative) support from a large sample of organisations. Thus, these findings support H6 and the assertions made by the relevant standards for innovation management systems.

Mastery of CSFs is also crucial to overcoming certification barriers, which can persist even during the maintenance stage (Ferreira and Cândido, 2021). There is a small but significant negative indirect effect of certification barriers on maintenance benefits through the mediation of CSFs (-0.307×0.336=-0.103, p=0.007; Figure 3). To counter this negative effect, organisations must demonstrate proficiency with CSFs. Thus, mastering CSFs is essential to mitigating this negative indirect effect of certification barriers on maintenance benefits and complementing the positive effect of other variables such as maintenance motivations (H5).

This analysis of the impact of maintenance CSFs on maintenance benefits is original in both the SIMS and ISO literature, as previous research has not addressed this relationship. While three ISO 9001 studies explore the relationship between maintenance activities and organisational performance (Arauz and Suzuki, 2004; Lo and Chang, 2007; Pan et al., 2009), they do not examine the relationship between CSFs and benefits (see Camango and Cândido, 2023). This study contributes to the literature by showing that SIMS maintenance CSFs are significant antecedents and predictors of SIMS maintenance benefits. Indirectly, it also supports the general innovation management literature that highlights the importance of CSFs for the success of non-certified innovation management systems (e.g., Tidd and Bessant, 2021:100,164-214,571-594).

Certification benefits have a moderate, positive, and statistically significant direct effect on maintenance benefits (0.363, p=0.000; Figure 2), contributing to explaining 72.3% of the variance in the latter variable (R^2=0.723), and supporting hypothesis H7. This indicates that the higher the certification benefits, the higher the maintenance benefits. Certification benefits, along with maintenance motivations and mastery of CSFs, are key contributors to maintaining the certification and reaping its benefits. Although maintenance benefits rely on all three variables, certification benefits have a slightly higher impact.

Certification benefits also help sustain initial certification motivations over time. Indirect effects of certification motivations through certification benefits are positive and significant: CMOT→CBEN→MBEN (0.280, p=0.000; Table 2, Panel D) and CMOT→CBEN→MMOT→MBEN (0.087, p=0.017), with a combined moderate and significant total indirect effect (0.280+0.087=0.367). Thus, initial certification motivations do not dissipate entirely but continue to impact maintenance benefits indirectly. (The direct effect is not significant: path (1) in Figure 3). These findings are original for the SIMS and ISO literature, as there is no previous research on these relationships.

Maintenance benefits are also sustained over long periods. Previous ISO 9001 research suggests that certification benefits can last throughout the certification validity period (three years) and beyond (*e.g*., Siougle *et al*. 2019), although this is debated (*e.g*., Lindlbauer *et al*., 2016; Cândido *et al*., 2021). This study shows that SIMS certification benefits can persist over multiple certification periods (three years each). The control variable ‘number of certification years’ has no significant impact on maintenance benefits (Section S1 in the Supplementary Materials), despite most sample firms being certified for two or more three-year periods (77.7%, Table S3 in the Supplementary Materials). Thus, SIMS maintenance benefits are sustained over long periods (more than 12 years, Table S3) and are not significantly related to time, firm size, industry, or other control variables in this research. Although previous research has concluded that size, industry and other variables (e.g., Castka, 2018; Mir *et al*., 2022; Clougherty and Grajek, 2023) can significantly affect certification success, these variables are not significant in this research. These findings are original for SIMS and contribute to the ISO literature by showing the long-term persistence of certification benefits.

6. Implications

6.1. Theoretical implications for SIMS research

Most research on standardised innovation management systems (SIMS) is conceptual, descriptive, or based on case studies. A major gap in the literature is the lack of analytic studies that develop empirical models establishing relationships between endogenous and exogenous variables. Specifically, the literature lacks a model of the performance impact of the certification and maintenance of SIMS. This study begins to fill that gap by analysing some of the most critical determinants of SIMS maintenance benefits and proposing an empirical model of the relationships between these variables.

Current research on SIMS’ performance impact indicates a positive impact of standardisation and certification on innovation capability and operational performance (Mir *et al*., 2016, 2022; Martínez-Costa *et al*., 2019; Espín et al., 2023). Similarly, studies on ISO 9001 and 14001 suggest a clear positive impact on operational performance (efficiency, quality, satisfaction, and cost), though the economic-financial impact of certified management systems is less conclusive (Kakouris and Sfakianaki, 2018). However, previous studies treat SIMS as an independent variable and do not consider antecedents of SIMS certification or the factors influencing SIMS maintenance (e.g., Mir *et al*., 2016, 2022; Martínez-Costa *et al*., 2019; Espín et al., 2023). Similarly, ISO 9001 and 14001 research suggests that the study of the impact of certification lacks the inclusion of contextual factors (Lo *et al*., 2013; Ferreira and Cândido, 2021; Cândido and Ferreira, 2022), particularly motives for certification (Tari *et al*., 2012) and certification barriers (Sun *et al*., 2019), to better explain the impact of certification on performance.

This study addresses these concerns by being the first to incorporate certain contingency factors into an empirical model, particularly maintenance motivations, maintenance CSFs, and maintenance benefits. These variables are absent from previous quantitative studies on SIMS (e.g., Mir *et al*., 2016, 2022; Martínez-Costa *et al*., 2019; Espín et al., 2023) and from the ISO literature (Camango and Cândido, 2023). The research model further distinguishes itself by including control variables that are relevant to the study of management systems performance but rarely employed in this context, including industry innovation degree, organisational innovation degree, and time with certification (e.g., Lindlbauer *et al*., 2016; Castka, 2018; Clougherty and Grajek, 2023). Alongside these, other more established control variables (firm age, size, and sector) are also incorporated (e.g., Castka, 2018; Mir *et al*., 2022; Clougherty and Grajek, 2023). The cited research has identified these variables as potentially influencing certification and performance. Their inclusion allows this study to assess their actual impact and to more precisely delimit the strength of the hypothesised relationships (Section S1).

The study reveals that SIMS maintenance, although highly demanding in terms of motivation, resources and effort, significantly positively impacts certification maintenance benefits. Specifically, the results show that certification motivations strongly affect certification benefits and moderately affect maintenance motivations. Certification motivations do not have a direct effect on maintenance benefits but exhibit a persistent moderate indirect effect, which must be complemented with strong maintenance motivations to generate substantial maintenance benefits. This means that in the long term, organisations cannot continue to rely on initial certification motivations, they need to develop maintenance motivations. These maintenance motivations, together with critical success factors and certification benefits, are significant antecedents (and predictors) with a moderate impact on certification maintenance benefits.

Certification barriers, in turn, have no direct effect on certification or maintenance benefits, but have a persistent detrimental indirect effect on maintenance benefits. This negative effect must be countered with the mastery of maintenance CSFs. The lack of a significant direct effect of barriers on certification benefits results from the segmented effect this variable has on certification/maintenance benefits. This study demonstrates that for some organisations the impact of barriers is negative, as hypothesised, but for others, the impact may be positive. This surprising and original result may be explained by social psychology and theory of constraints, but requires further study for substantiation and a deeper understanding.

Most importantly, the study contributes to the debate on whether innovation management systems can be standardised. While innovation is often viewed as inherently flexible and resistant to formalisation (Mir and Casadesús, 2011; Mir et al., 2016; Garechana *et al*., 2017; Tidd and Bessant, 2021:165) the feasibility and benefits of standardising innovation management remain underexplored (Mir et al., 2016; Alfaro, 2019; Saboya *et al*., 2025). By developing and testing a structural model linking several key antecedents of maintenance benefits, the study demonstrates that SIMS can be effectively implemented and maintained, generating enduring innovation and performance advantages. The findings clarify not only that the standardisation of innovation processes is feasible, but also how such standardisation can yield measurable benefits through the alignment of internal motivations, management practices consistent with the CSFs, and strategic orientations with innovation outcomes.

The study contributes also to social psychology theory by demonstrating that it can be extended and adapted to the context of SIMS, providing insights into organisational behaviour in terms of motivations and how organisations overcome barriers to maintain certification and achieve performance improvements. Importantly, it shows that, in the context of organisations, barriers can have a nuanced effect on performance.

To conclude this section, it is important to clearly distinguish between the contributions of this study and those of a previous publication by the same authors (Saboya *et al*., 2025). While Saboya *et al*. (2025) provides a foundational, descriptive and inductive exploration of the three stages of SIMS life cycle (certification, maintenance, and decertification) the present study advances the field through a sophisticated analytical and predictive methodology. Methodologically, Saboya *et al*. (2025) relies on descriptive statistics and binomial tests from 94 organisations to identify general trends in motivations and benefits. In contrast, this study draws on a slightly larger dataset (n=103) and employs PLS-SEM to test seven specific research hypotheses, establishing the first empirical model that explains and predicts how antecedents like critical success factors (CSFs), initial certification benefits and motivations drive maintenance performance.

The scientific contribution of the current study lies in its ability to model complex causal relationships and mediation effects that were only observed as parallel occurrences in Saboya *et al*. (2025). For instance, while Saboya *et al*. (2025) notes that internal motivations are prevalent in both certification and maintenance stages, this study demonstrates that initial certification motivations do not directly impact maintenance benefits; instead, their effect is mediated by maintenance motivations and the realisation of initial certification benefits, demonstrating the critical importance of nurturing maintenance motivations over time. Furthermore, this study provides a more nuanced theoretical perspective on certification barriers; while Saboya *et al*. (2025) characterises these obstacles as generally weak, this study uncovers a contingent relationship whereby barriers can have a positive impact on performance for organisations with a SIMS-misaligned strategy or for whom resource availability is not a critical maintenance factor, supporting a constraints-as-enablers logic. Finally, in the development of the model presented here (Figure 2), the study explores potential relationships (that were not hypothesised), showing that they are not significant or have a negligible impact (Figure 3, Section 4.5). Overall, the study clarifies not only that standardisation is beneficial, but also how these benefits can be effectively realised and sustained.

6.2. Theoretical implications for ISO research and generalisability

ISO 9001, ISO 14001 and SIMS standards, such as NP 4457 and UNE 166602, can be applied to firms of all sizes, complexity degrees, and economic sectors (AENOR, 2006; IPQ, 2007b; ISO, 2015a, 2015b, 2019). Any management system based on these standards can be certified by independent parties, if the organisation so chooses (AENOR, 2006; IPQ, 2007b; Cândido and Ferreira, 2022). These systems also share common aspects, such as the process approach, the plan-do-check-act cycle, continuous improvement, and several implementation CSFs (AENOR, 2006; IPQ, 2007b, ISO, 2015a, 2015b, 2019). All these standards have been developed to facilitate an easy integration of management systems. In particular, SIMS standards have been developed in alignment with ISO 9001, 14001, and other ISO standards to facilitate their integration (AENOR, 2006; IPQ, 2007b), sharing the same structure, process approach, plan-do-check-act cycle, and other elements.

Given the many common features among standards, it is reasonable to expect that several conclusions of the research on one of these systems may be applicable to others. Previous research suggests a degree of similarity or equivalence of findings across ISO standards (e.g., Tarí et al., 2012; Bernardo and Simon, 2014). Accordingly, some conclusions from this research on SIMS may be relevant to other ISO management systems, and vice versa. A notable example is the conclusions from hypothesis H1 (Section 5), which aligns with findings from ISO 9001 research.

However, caution is required when extrapolating results from one standard to another, as not all findings may generalise, particularly those related to certification benefits (e.g., Hernandez-Vivanco *et al*., 2019, Hernandez-Vivanco and Bernardo, 2023). Further research is needed to determine which relationships examined in this study are valid across different standards and certifications. In particular, ISO 9001 and 14001 require investigation of the hypotheses considered here, as most have not yet been studied in these contexts (see Camango and Cândido, 2023).

Overall, with the exception of H1, which has comparable findings in ISO 9001, further research is needed to clarify the conditions under which findings from one standard may validly be generalised to others, particularly for the hypotheses involving benefits (H5, H6, and H7).

6.3. Practical implications for organisations and governance of national innovation systems

There are practical implications for certified organisations. First, these organisations should be aware that certification barriers (e.g., insufficient qualifications, resistance to change), although having no direct effect on certification and maintenance benefits (e.g., improved innovation capability, improved performance), have a significant indirect effect on maintenance benefits, even after many years of certification. Considering how long the companies in this study have been certified (Table S3 in the Supplementary Materials), this effect can last 12 or more years after certification. This means that these barriers do not disappear after certification; they can persist and resurface over time. Managers must remain vigilant and continually address these barriers to ensure that maintenance benefits are fully realised over the long term.

The study also shows that mastering maintenance critical success factors is an important management tool to counter these persistent negative indirect effects of certification barriers. These factors have been demonstrated to be a crucial determinant of maintenance benefits. Effectively managing and leveraging these critical success factors can help organisations mitigate the long-term negative impacts of certification barriers and enhance their overall maintenance benefits. In practice, this means that organisations should prioritise the maintenance of the innovation management system by ensuring leadership commitment, fostering employee competence, cultivating a strong innovation culture, monitoring performance periodically, continuously improving the system, and keeping up to date, clearly documented processes.

This study's findings reframe how managers should think about certification barriers and CSF. Rather than treating barriers as implementation-stage problems to be resolved once and forgotten, managers must remain continuously vigilant, recognising that unresolved or resurging barriers will silently erode maintenance benefits over the long term. The practical implication is clear and actionable – organisations should systematically invest in the mastery of CSFs not as a compliance exercise but as a strategic mechanism for sustaining and amplifying the innovation and performance benefits of SIMS certification over multiple certification cycles.

This study further shows that the effect of certification barriers on performance is difficult to predict. The effect can be negative (the intuitive effect) or positive (a counterintuitive effect), depending on other factors. Managers should consider the degree of alignment between their strategy and the SIMS, as well as the importance placed on resource availability, to anticipate how barriers may influence certification and maintenance benefits.

The way managers handle these variables (strategy alignment and resource availability) can determine whether barriers have a positive or negative impact on certification and maintenance benefits. Organisations with a SIMS-aligned strategy may exhibit overconfidence in their strategy, which can hinder their ability to overcome higher certification barriers. Managers must moderate this overconfidence. Conversely, organisations with a SIMS-misaligned strategy may compensate through additional effort and resource allocation, rather than aligning their strategy with the SIMS. This compensation can help them overcome barriers and achieve substantial benefits despite misalignment. Nevertheless, managers in these organisations should also consider aligning their strategy with the SIMS, as alignment can reduce obstacles, enabling them to face lower barriers and achieve the desired maintenance benefits.

Similarly, organisations that consider resource availability an important maintenance CSF may become excessively reliant on their resources and struggle to overcome high barriers. In contrast, smaller organisations with limited resource pools tend to place less emphasis on resources for success and are often more adept at finding efficient ways to utilise them. While this study does not specifically investigate these solutions, it is reasonable to suggest that management in larger organisations could enhance resource efficiency when faced with higher certification barriers, rather than simply increasing resource allocation. As argued above, prioritising the maintenance of the innovation management system by effectively mastering the CSFs remains a more suitable approach to addressing certification barriers.

Second, certification motivations, although strongly influencing the initial certification benefits, have no direct effect on subsequent maintenance benefits. They do, however, exert a small but significant indirect effect that persists for more than 12 years. Managers must understand these different effects in order to manage maintenance motivations effectively. As the direct influence of certification motivations fades, organisations need to develop and sustain strong maintenance motivations to replace them. Top managers should therefore ensure that maintenance motivations are actively managed and reinforced, so that they compensate for the disappearing direct effect of certification motivations while complementing their remaining but limited indirect effect.

Third, certification benefits serve as a key stimulus for developing maintenance motivations. Management should make these benefits visible and accessible, as communicating the results achieved through certification helps foster the maintenance motivations necessary to sustain ongoing maintenance activities. Demonstrating the benefits provides a strong proof of concept, supporting the continued effective operation of the SIMS and the realisation of maintenance benefits. The empirical demonstration that maintenance motivations are a critical and manageable determinant of long-term SIMS benefits, and that these motivations can be deliberately cultivated by making certification benefits visible and communicating them systematically within the organisation is a significant practical contribution of this research. This finding is particularly valuable because it shifts managerial attention from the initial certification event, which tends to concentrate organisational effort and enthusiasm, to the less glamorous but arguably more consequential maintenance phase. Managers now have empirical evidence that the benefits of SIMS do not sustain themselves automatically; they require active motivational management, and the most effective way to sustain maintenance motivations is to ensure that the benefits achieved through certification are clearly measured, communicated, and attributed to the SIMS. This transforms what might otherwise be perceived as a routine compliance activity into a deliberate performance management cycle, with direct implications for how organisations design their internal innovation governance, reporting structures, and leadership engagement around their certified systems.

There are also practical implications for the governance of national innovation systems. For example, the number of certified SIMS in Portugal is currently very small (Section 3.1). Given the success of the certified organisations in this sample, in managing and deriving benefits from their SIMS (Section 4.1, Table 1), national innovation governance bodies should aim to incentivise a larger number of firms to adopt these standards. The results of this research help explain why the sample firms have been successful in implementing SIMS, and governance bodies can use these insights to support the effective implementation of SIMS in a broader set of organisations.

Specifically, governance organisations should focus on firms with a higher potential for maintaining SIMS – those that already possess some certification motivation, particularly internal or intrinsic motivation, and are more likely to derive substantial certification benefits because they demonstrate mastery of the CSFs. Ensuring that these selected firms obtain certification benefits is crucial both at the outset of the process (as proof of concept) and throughout subsequent maintenance years, as these benefits help reinforce and sustain maintenance motivations. Expanding successful SIMS implementation across a larger group of motivated organisations could enable society to allocate its limited resources more effectively, promoting innovation and greater overall prosperity.

Lastly, there are also implications for innovative, yet uncertified, organisations that are considering certifying their innovation management systems. The findings of this study can help these organisations make more informed decisions. Such organisations should implement a SIMS and pursue certification, taking into account the benefits achieved by previously certified organisations (Table 1), but only if they possess a sufficient level of motivation. Adequate motivation from the outset is essential to generate early moderate to strong certification benefits, which are necessary to foster maintenance motivations. These maintenance motivations, in turn, serve as a key driver of persistent and sustainable maintenance benefits. Additionally, mastery of the CSFs is critical for managing potential certification barriers, which can have a long-lasting indirect negative effect, persisting even during the maintenance phase of certification (extending beyond 12 years).

In summary, key priorities are highlighted for different stakeholders. Certified organisations should monitor barriers, avoid overconfidence in strategy and resources, make benefits visible to increase motivations, and focus on effective mastery of CSFs. Governance bodies should aim to increase the number of certified firms, prioritise those with intrinsic motivation, and ensure benefits are measured and communicated to reinforce motivation. Innovative, yet uncertified organisations should pursue certification only if motivated, secure early benefits, communicate them, and mitigate barriers through mastery of CSFs. These implications aim to enhance organisational innovation and performance, inform incentive design, and contribute to broader societal impact.

7. Limitations

The study has several limitations that suggest avenues for further research. First, it focuses on NP 4457:2007. Although this standard shares a common structure and core aspects with other standards (e.g., process approach, plan-do-check-act cycle, continuous improvement, and several implementation CSFs), future research should investigate different SIMS to assess the generalisability of the study's findings across diverse certification frameworks. Evidence from research on multiple management systems based on ISO 9001, ISO 14001, and other standards indicates that, despite their shared high-level structure and core concepts, their organisational impacts and performance outcomes may differ.

Second, the study concentrates on organisations from a single European country and does not focus on specific industries. Accordingly, the results are limited to their geographical context. While Portugal presents contextual similarities with other European economies, national and cross-national investigations covering other regions and institutional settings would enhance the external validity of the results and offer a broader understanding of SIMS adoption, maintenance, and impact on a global scale.

Third, the study is based on self-reported data, which is common in organisational and management research, particularly when the variables of interest are not easily observable (e.g., motivations, barriers, perceived benefits). To mitigate potential biases related to respondents' perceptions or interpretations, several ex-ante and ex-post procedures were adopted (sections 3.2, 3.3 and 4.2). Future research could complement self-reported data with objective performance indicators or external audits to strengthen the robustness and validity of the findings.

Fourth, the cross-sectional nature of the data used in this study constrains the ability to infer causal relationships between the examined variables. Future research could address this limitation by collecting longitudinal data and employing analytical approaches such as panel data methods, which would enable a more robust assessment of causal effects and the dynamic interactions among certification, maintenance, and performance outcomes.

Fifth, while the research model explains 72.3% of the variance in the main dependent variable, which is very good, it does not differentiate between internal and external variables (e.g., internal vs external motivations and benefits). Future studies could explore this differentiation to better understand how internal and external factors influence SIMS outcomes.

Lastly, future research could explore other variables such as organisational culture, leadership support (Mir et al., 2016; Tidd and Bessant, 2021), certification maintenance obstacles, maintenance activities (Wahid and Corner 2009; Castka, 2018), technology intensity, industry competitiveness (Lo *et al*., 2013), market uncertainty, institutional pressures, government incentives, organisational inertia, and social influences (Castka, 2018; Gonçalves *et al*., 2020; Gimenez- Fernandez et al., 2021).

8. Conclusion

This study advances the understanding of standardised innovation management systems by examining the determinants of certification and maintenance benefits. Using data from 103 Portuguese organisations certified in SIMS and employing PLS-SEM, the research develops a comprehensive model that connects motivations, barriers, critical success factors, and benefits across the certification and maintenance stages, thereby addressing a major gap in the literature and achieving the study's primary objective.

Findings show that SIMS maintenance exerts a significant effect on maintenance benefits, underscoring its central role in sustaining innovation and organisational performance. Certification motivations strongly influence certification benefits and moderately shape maintenance motivations but do not directly generate maintenance benefits; their impact is mediated by maintenance motivations and certification benefits. Maintenance motivations, CSFs, and certification benefits emerge as key predictors of maintenance benefits. Although certification barriers do not directly affect benefits, they exert a persistent indirect negative influence, highlighting the importance of effectively managing CSFs throughout the certification life cycle. Additionally, two subsets of organisations display contrasting relationships between barriers and benefits (one negative and the other positive) reflecting differences in strategic alignment with SIMS and in the perceived relevance of resource availability.

Theoretically, this study provides the first empirical model of SIMS maintenance benefits, extending the literature on innovation management standardisation and offering a transferable analytical framework applicable to other ISO-based management systems. Practically, organisations should align their strategies with the SIMS principles, cultivate strong internal motivations for certification and maintenance, master the critical success factors for maintenance, and optimise resource efficiency to overcome barriers – rather than merely increasing resource allocation – in order to maximise long-term benefits. Policymakers and standardisation bodies can draw on these insights to design support mechanisms that promote maintenance and recertification, thereby reinforcing national innovation systems and competitiveness.

In conclusion, SIMS can deliver sustained innovation and performance benefits when internal motivations, strategic orientation and CSFs are effectively aligned over time. Future research should adopt longitudinal and cross-national approaches to explore how evolving motivations and organisational dynamics influence sustained certification outcomes.

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Declaration of generative artificial intelligence (AI) and AI-assisted technologies in the writing process

In the later stages of development of this manuscript, the authors employed AI language models to enhance the overall readability: ChatGPT-4, developed by OpenAI, and Claude Sonnet 4.6, developed by Anthropic. The authors subsequently reviewed and edited the content, acknowledging complete responsibility for the final substance of the publication.

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.

Data availability

The data used in this study are confidential. Due to the sensitive nature of the questions asked in this study, survey respondents were assured that raw data would remain confidential and would not be shared.

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Supplementary Materials

Contents:

S1. Control variables

The study considers several control variables: firm age, number of years with NP 4457 certification, firm size (measured by employees and business volume), degree of perceived organisation innovation, activity sector (industry or services), and degree of perceived industry innovation (see Table S3 in this Supplementary Materials file). These variables have been shown to have significant impact on some of the variables in the research model, including certification and the performance of certified firms (*e.g*., Lindlbauer *et al*., 2016; Manders *et al*., 2016; Castka, 2018; Zayas-Mateo and Martínez-Lorente, 2021; Bravi and Murmura, 2022; Mir *et al*., 2022; Clougherty and Grajek, 2023). In this study, however, these variables have no significant impact on SIMS certification maintenance benefits. Effect sizes are very small (from -0.135 to 0.084), and their p-values are all above 0.05 (from 0.068 to 0.691). In addition, introducing the control variables does not change the significance (insignificance) of the structural coefficients in the research model (Figure 2), nor the magnitudes of the structural coefficients which remain almost unchanged.

S2. Endogeneity analysis

Endogeneity is a severe problem that can introduce bias in the model estimates. Endogeneity was addressed in this study by carefully developing the measurement instrument (Section 3.3), avoiding data collection bias (Section 3.2), testing for sampling bias (Section 4.2), analysing the effects of several control variables (Section S1), and testing for the presence of endogeneity with the Gaussian copula method.

For the latter method, the researchers added copulas to all relationships in the research model. The results suggest that there are no endogeneity problems, as the p-values for all copulas are higher than 0.05 (p-values vary from 0.125 to 0.528). These tests are performed under the assumption that none of the involved latent variables are normally distributed. However, that is not the case for one of the variables (certification barriers). The Cramér-Von Mises p-value for this variable is 0.877, suggesting that this variable may have a normal distribution. Consequently, the result of the endogeneity test for the relationship between barriers and benefits should be considered more carefully, even if it points to a lack of endogeneity. To further test the threat of endogeneity, the variable certification barriers was temporarily excluded from the research model. This exclusion is acceptable because this variable has no significant effect on other variables (H4 is rejected). After removing this variable from the model, the repetition of the tests suggests that there are no endogeneity issues in any of the statistically significant relationships of the research model ($p>0.05$), with all assumptions being met.

S3. Heterogeneity analysis

The analysis in the previous section might suggest possible heterogeneity problems. To investigate this possibility, a heterogeneity analysis was conducted using the recommended permutation procedure (Hair et al., 2022:289). This procedure includes both a test for the invariance of the measurement model and a test for the difference between the structural coefficients of two halves of the main sample (Hair et al., 2022). For this procedure, several moderating variables (or splitting variables) can be considered to split the sample in halves, including business volume (micro-small vs medium-large companies), sector (industry vs. services), organisational innovation degree (very innovative vs not very innovative), and the two variables considered in the previous section (CBAR4 and MCSF5). Unfortunately, this analysis is not possible for MCSF5, given the size of one of the subsamples.

Full measurement invariance was established for the subsamples built with the splitting variable business volume. Partial measurement invariance (Hair *et al.*, 2022) was also established for all other subsamples. Since at least partial invariance has been established for all subsamples, the next step is to assess the differences between structural coefficients. There are no significant differences between the structural coefficients of all pairs of subsamples ($p>0.05$), except for those built with the splitting variable CBAR4. Importantly, in the case of the subsamples obtained with this splitting variable (CBAR4), there were no differences for the statistically significant coefficients in the main research model in Figure 2. That is, for all coefficients corresponding to the supported research hypotheses. The CBAR→CBEN coefficient, however, shows a significant difference ($p<0.05$), as suggested by the analysis in the previous section (Table 4). Globally, this heterogeneity analysis suggests that the statistically significant coefficients in the SEM model in Figure 2 are valid for the whole sample, and the insignificance of the coefficient CBAR→CBEN is due to a difference between two structural coefficients, one for the subsample of CBAR4 = 1 or 2 and one for the subsample CBAR4 = 3, 4, or 5 (Cf. Table 4). Thus, there are no heterogeneity problems with the statistically significant coefficients in the SEM model of Figure 2.

This heterogeneity analysis has a limitation. The a priori minimum sample size (69, Section 3.1) was determined to ensure a power level of 80% and a significance level of 5%. This sample size requirement is satisfied for all statistical tests conducted in this study (with a sample size of 103), except for part of the heterogeneity tests performed in this section, which necessitate dividing the sample into two halves.

S4. Sensitivity analysis (n=94 vs. n=103)

This section compares the structural coefficients and p-values obtained from the structural model estimated with 94 observations to those from the model estimated with the full sample of 103 observations. The results presented in table S6 indicate that all significant coefficients remain significant at the same level of significance, and the previously insignificant coefficient remains insignificant. The largest absolute change in these coefficients is only 0.045, observed for hypothesis H7. Similarly, the largest absolute change in p-values is 0.004 for the significant coefficients and 0.116 for the insignificant one.

These results demonstrate that there are no relevant differences between the model estimated with 94 and 103 observations. However, the larger sample size offers an important advantage, namely an increase in the statistical power of the tests (see Section 3.1).

Table S1. Measurement instrument: certification motivations, barriers and benefits

Variable and indicators (Reflective)	Management system	Studies
Certification motivations (CMOT)	NP 4457	Santos *et al.*, 2019.
Increase in the company's ability to innovate (CMOT1) Increase in the company's competitiveness (CMOT2) Increased customer satisfaction and trust (CMOT3) Creating value for customers (CMOT4)	UNE 166002 and other systems or standards of innovation management	Correa *et al.*, 2007; Badrinas and Vilà, 2015; Mir *et al.*, 2016; Araya and Paz, 2019.
Development of a culture of innovation (CMOT5) Business development and growth (CMOT6) Improvement of the company's image (CMOT7) Improved company performance (CMOT8)	ISO 9001	Lo and Chang, 2007; Sampaio *et al.*, 2014; Djofack and Camacho, 2017; Kakouris and Sfakianaki, 2018; Ferreira and Cândido, 2021.
Certification barriers (CBAR) Low qualification of staff (CBAR1)	NP 4457	Lopes *et al.*, 2012; Caetano, 2017; Santos *et al.*, 2019.
Organizational culture (CBAR2) Cost of SIMS implementation and certification processes (CBAR3) Misalignment of the SIMS with strategy (CBAR4) Organizational structure not conducive to innovation (CBAR5)	UNE 166002 and other systems or standards of innovation management	Mir and Casadesús, 2011; Pellicer *et al.*, 2012; Martínez-Costa *et al.*, 2019.
Lack of commitment and support from senior management (CBAR6) Lack of a systemic approach to innovation management (CBAR7) Insufficient resources (time, money, personnel, equipment, materials, and others…) (CBAR8) Formal, complex and time-consuming process (CBAR9) Resistance to change (CBAR10)	ISO 9001	Cândido and Santos, 2011; Sampaio *et al.*, 2014; Esgarrancho and Cândido, 2020; Sfakianaki and Kakouris, 2020; Ferreira and Cândido, 2021; Cândido and Ferreira, 2022, 2023.
Certification benefits (CBEN) Easy access to tax benefits and financing (CBEN1)	NP 4457	Lopes *et al.*, 2012; Caetano, 2017; Santos *et al.*, 2019.
Increased customer satisfaction and trust (CBEN2) Creating value for customers (CBEN3) Development of a culture of innovation, communication and internal discussion (CBEN4) Business development and growth (CBEN5) Improved capacity for innovation (CBEN6)	UNE 166002 and other systems or standards of innovation management	Correa *et al.*, 2007; Mir and Casadesús, 2011; Pellicer *et al.*, 2012; Mir *et al.*, 2016; Yepes *et al.*, 2016; Garechana *et al.*, 2017; Cerezo-Narváez *et al.*, 2019; Martínez-Costa *et al.*, 2019; Idris and Durmuşoğlu, 2021; Khan *et al.*, 2021.
Improved company competitiveness (CBEN7) Improvement of company image (CBEN8) Improved company performance (CBEN9)	ISO 9001	Djofack and Camacho, 2017; Kakouris and Sfakianaki, 2018; Ferreira and Cândido, 2021; Cândido and Ferreira, 2022, 2023.

Rating scale: very weak (1), weak (2), average (3), strong (4), very strong (5).
Source: adapted from Saboya et al. (2025)

Table S2. Measurement instrument: maintenance motivations, critical success factors and benefits

Variable and indicators (Reflective)	Management system	Studies
Maintenance motivations (MMOT) Customer requirement to maintain certification (MMOT1) Business expansion (MMOT2) Greater ability to anticipate market requirements (MMOT3) Maintenance of certification benefits (MMOT4) The company's need to remain competitive (MMOT5) Pressure from stakeholders for certification maintenance (MMOT6) Promotion of continuous improvement (MMOT7) Fear of losing the certificate (MMOT8) Reinforcement of the company's innovation culture (MMOT9)	ISO 9001	Low and Omar, 1997; Water, 2000; Wahid *et al.*, 2011; Castka, 2018.
Maintenance critical success factors (MCSF) Ability of staff to work as a team (MCSF1) Commitment and support from senior management (MCSF2) Organizational culture and climate conducive to change, innovation and improvement (MCSF3) Definition, documentation and clear communication of assignments, responsibilities and authorities (MCSF4) Availability of resources (time, money, personnel, equipment, materials, and others) (MCSF5) Focus on continuous improvement (MCSF6) Training of the personnel involved (MCSF7) Motivation and commitment of workers (MCSF8) Collaborative relationship with suppliers and subcontractors (MCSF9) Performance recognition and/or reward system (MCSF10)	ISO 9001	Low and Omar, 1997; Wahid and Corner, 2009; Wahid *et al.*, 2011; Sanchez-Lizarraga *et al.*, 2020.
Maintenance benefits (MBEN) Development of a culture of innovation, communication and internal discussion (MBEN1) Business expansion (MBEN2) Maintenance of certification benefits (MBEN3) SIMS maturity (MBEN4) Improved innovation capability (MBEN5) Improved trust between stakeholders (MBEN6) Improved company performance (MBEN7) Customer satisfaction (MBEN8) Systematization and improvement of processes (MBEN9)	ISO 9001	Lo and Chang, 2007; Wahid and Corner, 2009; Wahid *et al.*, 2011; Castka, 2018.

Rating scale: very weak (1), weak (2), average (3), strong (4), very strong (5).
Source: adapted from Saboya et al. (2025)

Table S3. Sample descriptive statistics

Sample characteristics	Frequency	Percent
Respondent position	103	100.0
Director / manager	52	50.5
Innovation manager	47	45.6
Other positions	4	3.9
Employee number	103	100.0
<10	10	9.7
10-49	28	27.2
50-249	39	37.9
>250	26	25.2
Business volume (euros)	103	100.0
<2,000,000	23	22.3
2,000,000 - 10,000,000	39	37.9
10,000,000 - 50,000,000	26	25.2
>50,000,000	15	14.6
Years certified (NP 4457:2007)	103	100.0
<3	23	22.3
3-6	28	27.2
6-9	20	19.4
9-12	22	21.4
>12	10	9.7
Organisation's degree of innovation	103	100.0
Scarcely innovative	11	10.7
Innovative	67	65.0
Very innovative	25	24.3
Activity sector	103	100.0
Industry	44	42.7
Services	59	57.3
Activity sector innovation degree	103	100.0
Not innovative	1	1.0
Scarcely innovative	15	14.6
Innovative	57	55.3
Very innovative	30	29.1

Source: Survey data

Table S4. Measurement model statistics

Latent variables	Item	n	Mean	SD	Excess kurtosis	Skewness	Cramér-von Mises p-value	Loading
Certification motivations	CMOT1	103	3.777	0.881	0.067	-0.496	0.000	0.817***
	CMOT2	103	3.709	1.001	-0.402	-0.385	0.000	0.881***
	CMOT3	103	3.592	0.939	0.250	-0.521	0.000	0.799***
	CMOT5	103	4.019	0.892	1.212	-0.955	0.000	0.763***
	CMOT6	103	3.631	0.903	0.297	-0.641	0.000	0.823***
	CMOT7	103	3.932	0.884	1.143	-0.892	0.000	0.765***
	CMOT8	103	3.748	0.889	0.097	-0.570	0.000	0.805***
Certification barriers	CBAR1	103	2.485	1.042	-0.539	0.170	0.000	0.658***
	CBAR2	103	2.835	1.133	-0.651	-0.075	0.000	0.765***
	CBAR5	103	2.437	1.180	-0.377	0.603	0.000	0.819***
	CBAR6	103	2.010	1.102	0.233	0.953	0.000	0.773***
	CBAR7	103	2.689	1.106	-0.761	0.164	0.000	0.727***
	CBAR8	103	2.757	1.038	-0.643	0.082	0.000	0.761***
	CBAR9	103	2.883	1.046	-0.544	0.030	0.000	0.679***
Certification benefits	CBEN2	103	3.340	1.020	-0.175	-0.504	0.000	0.862***
	CBEN3	103	3.592	0.960	0.833	-0.902	0.000	0.887***
	CBEN5	103	3.369	0.914	0.207	-0.573	0.000	0.914***
	CBEN7	103	3.408	0.929	0.221	-0.537	0.000	0.924***
	CBEN9	103	3.466	0.845	0.747	-0.674	0.000	0.867***
Maintenance motivations	MMOT2	103	2.990	1.153	-0.716	-0.174	0.000	0.797***
	MMOT3	103	3.447	1.068	-0.244	-0.587	0.000	0.795***
	MMOT4	103	3.680	0.987	0.088	-0.605	0.000	0.669***
	MMOT5	103	3.563	1.030	-0.378	-0.496	0.000	0.864***
	MMOT7	103	3.864	0.860	-0.473	-0.383	0.000	0.726***
Maintenance critical success factors	MCSF1	103	3.825	0.781	-0.022	-0.424	0.000	0.849***
	MCSF2	103	3.942	0.922	-0.651	-0.485	0.000	0.794***
	MCSF3	103	3.767	0.957	0.063	-0.592	0.000	0.865***
	MCSF7	103	3.573	0.843	0.538	-0.430	0.000	0.726***
	MCSF8	103	3.650	0.844	-0.477	-0.239	0.000	0.817***
Maintenance benefits	MBEN1	103	3.845	0.911	0.074	-0.622	0.000	0.824***
	MBEN4	103	3.825	0.908	1.474	-1.067	0.000	0.826***
	MBEN5	103	3.777	0.892	1.375	-0.960	0.000	0.891***
	MBEN6	103	3.350	0.952	-0.007	-0.757	0.000	0.760***
	MBEN9	103	3.883	0.780	1.359	-0.789	0.000	0.770***

Notes: All items measured on a five-point Likert scale. *** Significant at the 1 percent level. Bilateral p-values.

Table S5. Predictive power (PLS predict)

Item	Q^2 predict	PLS-SEM RMSE	PLS-SEM MAE	LM RMSE	LM MAE
CBEN2	0.447	0.768	0.585	0.860	0.660
CBEN3	0.420	0.742	0.558	0.933	0.702
CBEN5	0.501	0.654	0.478	0.822	0.599
CBEN7	0.485	0.672	0.518	0.801	0.615
CBEN9	0.441	0.640	0.497	0.756	0.590
MMOT2	0.256	1.003	0.782	1.198	0.919
MMOT3	0.289	0.911	0.706	1.172	0.887
MMOT4	0.170	0.912	0.718	1.095	0.829
MMOT5	0.421	0.790	0.614	0.942	0.739
MMOT7	0.306	0.722	0.587	0.802	0.630
MBEN1	0.546	0.620	0.498	0.658	0.502
MBEN4	0.311	0.763	0.567	0.913	0.680
MBEN5	0.494	0.643	0.502	0.763	0.583
MBEN6	0.356	0.770	0.581	0.907	0.685
MBEN9	0.240	0.688	0.516	0.788	0.593

Table S6. Comparison of PLS-SEM structural model results (n = 94 vs. n = 103)

Hypothesis		Expected effect	Path coefficient (n=94)	p-value (n=94)	Path coefficient (n=103)	p-value (n=103)	Decision	|Δcoefficients| (n=94 vs. n=103)	|Δp-values| (n=94 vs. n=103)
H1	CMOT→CBEN	(+)	0.793***	0.000	0.772***	0.000	Supported	0.021	0.000
H2	CMOT→MMOT	(+)	0.364***	0.005	0.377***	0.001	Supported	0.013	0.004
H3	CBEN→MMOT	(+)	0.437***	0.002	0.434***	0.001	Supported	0.003	0.001
H4	CBAR→CBEN	(–)	-0.010 n.s.	0.433	-0.028 n.s.	0.317	Not Supported	0.018	0.116
H5	MMOT→MBEN	(+)	0.264***	0.001	0.259***	0.001	Supported	0.005	0.000
H6	MCSF→MBEN	(+)	0.307***	0.000	0.349***	0.000	Supported	0.042	0.000
H7	CBEN→MBEN	(+)	0.408***	0.000	0.363***	0.000	Supported	0.045	0.000

Notes: n.s. Not significant, *** Significant at the 1 percent level. Unilateral p-values.

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