

The influence of ISO 9001 on business entropy in the South African packaging industry

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ABSTRACT

Failure to manage business entropy in an organisation can lead to increased process variation and inefficiencies, highlighting the need to have structured mechanisms in place to stabilise organisational processes. The aim of this study was to investigate the influence of ISO 9001 Quality Management System (QMS) on business entropy within the South African (SA) packaging industry. The study incorporated a convergent parallel mixed methods research design to explore how the standard contributes to entropy reducing factors such as process optimisation, waste reduction, continual improvement, and supplier management. The quantitative part of the study included a survey questionnaire to collect data from 113 respondents through stratified sampling. The qualitative part of the study adopted an interview guide to collect data from 26 senior managers also through stratified sampling. The quantitative data was analysed using descriptive and inferential statistics, while the qualitative data was analysed through thematic analysis. The findings indicated that ISO 9001 helps reduce business entropy through standardised processes, process monitoring controls and continuous improvement. However, these improvements were mainly noted at the operational level and tended to be reactive to day-to-day challenges as opposed to proactively implementing improvements to reduce disorder. In addition, it was established that while the standard focuses on maintaining process stability, its effectiveness in

reducing entropy may require the adoption of other complimentary techniques such as Lean, Six Sigma and Business Process Reengineering (BPR) to provide robust measures against system disorder. The study proposes a business entropy management framework based on the PDCA cycle to continuously analyse, improve and manage system disorder. The framework incorporates entropy based measurements, together with Lean, Six Sigma, BPR techniques to track variations and efficiencies across all processes.

Keywords: ISO 9001, entropy, process integration, operational efficiency, organisational performance

INTRODUCTION

The concept of entropy, which was originally developed in thermodynamics as a means to measure the extent of disorder in physical systems, has been extended over the years to examine the extent of disorder in a business context (Korablev *et al.*, 2018). In this setting, it helps to explain the uncertainty and inefficiency in complex business processes so that measures can be implemented to counter these inefficiencies (Ceptureanu *et al.*, 2017; Smunt and Ghose, 2016; Martínez-Berumen *et al.*, 2014).

According to the principle of increasing entropy and its application in manufacturing environments, Markyna and Dyachkov (2014) highlighted that entropy is a state function of the system; and thus, if the system has high entropy it would subsequently correspond to higher disorder throughout the system. Xi *et al.* (2014) used pairwise maximum entropy models to underscore the complexity of economic systems and how higher-order interactions and system size significantly influenced systemic entropy. Similarly, Korablev *et al.* (2018) compared business systems to thermodynamic systems, where internal subsystems fluctuate between order and disorder, reinforcing the idea that businesses naturally tend toward increasing entropy without proactive management. From a strategic perspective, Durmaz *et al.* (2021) introduces the concept of negative entropy to promote supply chain sustainability, by demonstrating how structured collaboration and governance practices can effectively counteract systemic disorder. These inherent tendencies toward disorder manifests in business as operational inefficiencies, misalignment between departments, poor communication, and unclear strategic direction (Ursacescu and Cioc, 2016; Sanidas,

2008). Given these typical system disorders, the concept of entropy can therefore provide a useful framework for managing organisations process efficiencies in the current volatile and complex business environments (Smunt and Ghose, 2016).

However, while the literature provides insights into business entropy as a measure of disorder and risk, Ceptureanu *et al.* (2017) highlighted that ongoing research is necessary to continuously investigate mechanisms through which organisations can systematically reduce entropy to achieve sustainable performance. To this end, Lollai (2017) asserts that understanding and applying entropy to organisational quality management is a new initiative and a fresh approach to improving an organisation's effectiveness. The author presented a Quality Systems Theory perspective that interprets Quality Management Systems (QMS's) through a thermodynamics-based lens, proposing entropy measures such as virtual document entropy and process-based entropy, while also drawing parallels with cybernetics and information theory. Similarly, He (2022) proposes that the ISO 9001:2015 standard and continuous improvement methodologies such as Lean and Six Sigma techniques are structured, process-driven approaches that align closely with entropy-reducing principles. By establishing standard operating procedures, clarifying roles and responsibilities, enabling feedback loops, and promoting data-driven management, Ivanov *et al.* (2025) asserts that ISO 9001:2015 can help reduce disorder within a business system from an entropic perspective. This is mainly due to the ISO 9001:2015 standard placing strong emphasis on a risk-based approach to quality management, continual improvement, evidence-based decision-making, and process integration of all operations within an organisation (Roopnarian *et al.*, 2023; Chiarini and Cherrafi, 2023).

he three aspects influencing total system entropy, namely business scale, business complexity, and business knowledge, is commonly used to minimise entropy in each stage of the business life cycle (Jing, 2012). Failure to manage the business entropy effectively could subsequently result in increased process variation, quality defects, inefficiencies, and ultimately business failure (He, 2022). Therefore, the aim of this study was to investigate the influence of ISO 9001:2015 on business entropy within the South African Packaging sector. This sector makes a significant contribution to South African economy in terms of job creation and transformation, and thus business efficiency and QMS's driving this sector is important and requires ongoing

improvements (Braithwaite *et al.*, 2019). The study was guided by the following three research questions:

- How does the ISO 9001:2015 practices affect business entropy in the SA packaging sector?
- Which ISO 9001:2015 practices contribute most effectively to reducing operational inefficiencies and process variations?
- What strategy should be considered to get the maximum benefits of ISO 9001:2015 on business performance?

RESEARCH METHODOLOGY

The study adopted a convergent parallel mixed methods research design to evaluate the QMS practices that align to entropy factors that affect organisational performance in the South African packaging sector. This methodology entailed collecting both quantitative and qualitative data separately as a means to capitalise on the strengths on both techniques (Creswell and Creswell, 2018; Leavy, 2017). The quantitative part of the study incorporated a survey questionnaire to collect primary data from shop floor management employees, while the qualitative part of the study used an interview guide to capture deeper insights from senior level managers. The both sets of data were collected concurrently but analysed separately. The study used methodological triangulation techniques to strengthen the reliability of the results (Leavy, 2017).

Sampling

The target population for this study were 160 packaging manufacturers in South Africa holding ISO certification, as identified through Packaging SA (2020). The sample size for the quantitative part of the study was determined using Krejcie and Morgan's (1970) statistical model for calculating sample sizes from finite populations (Sekaran and Bougie, 2016). Therefore, based on a 95% confidence level, 5% margin of error, and 50% population proportion, the table recommends a sample size of 113, which was considered appropriate for this study. For the qualitative part of the study, a sample size of 20 participants was deemed sufficient to capture information that will reach data saturation (Leavy, 2017).

The packaging Industry in South Africa is made up of five segments of packaging materials namely glass, paper, plastic, metal and other substrates (Braithwaite *et al.*, 2019). These companies are spread throughout the country, and therefore the study adopted the stratified sampling technique as a means to capture data from all segments of the packaging industry. This can be supported by Sekaran and Bougie (2016) who noted that a stratified sampling technique is particularly effective when differentiated information is required from distinct subgroups within a population.

Questionnaire design and interview guide

The survey questionnaire was informed by the ISO 9001:2015 standard and He (2022) to collect empirical data on entropy reducing factors such as operational efficiency, leadership support, process optimisation and overall business performance. It consisted of ten closed-ended questions, and the respondents were required to indicate their level of agreement or disagreement for each statement on a 5-point Likert scale. The Likert scale was selected as it is a reliable scale to measure attitude in a scientifically accepted manner (Rokeman, 2024). In addition, the survey was kept short so that the respondents did not feel overwhelmed to complete the questionnaire. A pilot test was conducted with ten participants to assess the clarity of the questionnaire and to detect if there were any ambiguous wording with the questions.

The questions for the interview guide were designed to collect in-depth information on the entropy reducing factors aligned to the ISO 9001:2015 standard and continuous improvement methodologies (He, 2022). It consisted of nine open-ended questions that were aligned to the survey questionnaire so that triangulation could be performed and to enhance the validity of the data as suggested by Leavy (2017). The interviews aimed to uncover high-level insights into how the standard influenced internal business processes, strategic decision-making, quality culture, and continuous improvement practices. By targeting leaders and decision-makers, the interviews provided detailed perspectives on the drivers, challenges, and outcomes associated with ISO 9001 effectiveness in the sector.

Data collection

For the quantitative component of the study, the surveys were distributed via email to the selected respondents. The contact details for the selected respondents were obtained from Packaging South Africa (PSA), which serves as the collective voice of

the South African packaging industry on matters related to packaging. The surveys were distributed over a three-month data collection period.

For the qualitative component, the interview participants were also identified through the PSA database. A total of 26 senior managers representing various sectors of the packaging industry were contacted via email and telephone. The purpose and scope of the study were clearly communicated, and all 26 managers agreed to participate. Over 60% of the interviews were conducted face-to-face, while the remaining sessions were conducted telephonically due to participants' limited availability and scheduling constraints. Each interview lasted approximately 50 minutes. The researchers documented responses using a laptop, striving to capture participants' exact wording as closely as possible. After each interview, the recorded responses were reviewed for grammatical accuracy and clarity of expression without altering the core meaning. A copy of each transcript was emailed to the respective participants to verify if all the information captured from the interview was correct. All participants acknowledged the transcripts and confirmed that the information captured was accurate.

Data analysis

The quantitative data of the study was analysed with the Statistical Package for Social Science version 26. The analysis included frequency distributions to summarise and describe the data. The qualitative data collected through the interviews was captured on Microsoft Excel and analysed through thematic analysis. The purpose of thematic analysis is to identify, analyse and report patterns of information from qualitative data (Lochmiller, 2021). In addition, it allows for a comprehensive interpretation of the qualitative data by exploring the various dimensions of the participant feedback. Therefore, the qualitative data in this study was arranged based on content analysis, where the frequency of responses were grouped into meaningful categories and subsequently aligned to specific themes and sub-themes. According to Ozden (2024), this type of analysis allows the researcher to iteratively examine the data and then transition from a broad overview of the data to the identification of patterns and key themes.

Data reliability and validity

The reliability of the survey questionnaire was ensured through the Cronbach's coefficient alpha value, where a value of 0.7 and above is considered acceptable

according to Surucu and Maslakci (2020). The study obtained a coefficient value of 0.85 for the 10 constructs, which confirmed the high reliability of the survey questionnaire. In addition, the validity of the survey questionnaire was confirmed through content validity principles which entailed industry experts reviewing the questions to ensure that it covered all areas of the concepts being investigated (Sekaran and Bougie, 2016).

The reliability of the interview process was ensured through trustworthiness based on dependability and credibility. The dependability of the study was maintained by ensuring that the research process was clearly documented so that it could be replicated by other researchers as noted by Ahmed (2024). In addition, the credibility of the study was maintained by ensuring that the data collected reflected a comprehensive representation of quality management practices. Additionally, the recorded minutes of the qualitative interviews were shared with the participants so that they could validate and confirm that the recorded information was captured correctly.

The study adopted methodological triangulation, which according to Leavy (2017) refers to the use of more than one method to study the same research question, to strengthen the reliability of the results. According to Flick *et al.* (2018) triangulation is commonly used to validate data through cross verification from more than two sources of information. Therefore, the quantitative data from the survey and the qualitative data from the interviews were triangulated across various areas to strengthen the study findings.

RESULTS AND DISCUSSION

Quantitative results

The results from the survey questionnaire are presented in Table 1.

Table 1 – Survey questionnaire results

ID	Since ISO 9001 implementation:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
S1	There has been a reduction in process wastage	1.8	23.9	32.7	31.0	10.6
S2	The business processes are clearly defined through process mapping	2.6	0.9	21.9	44.7	29.8

S3	The business processes are analysed and engineered to remove non-value adding steps	2.6	7.9	40.4	35.1	14.0
S4	There have been significant changes to business processes	3.6	9.1	28.2	42.7	16.4
S5	Routine formal quality management reviews lead to changes in business processes	2.7	4.4	32.7	36.3	23.9
S6	Business data across the functional areas are collected and analysed for decision making	0.9	5.2	17.4	49.6	27.0
S7	There is a strong emphasis on sustained Continual Improvement methodologies across all functional areas of the business	2.6	1.7	19.1	54.8	21.7
S8	Leadership provides resources for Continual Improvement	0.9	1.7	21.7	36.5	39.1
S9	Routine formal quality management reviews promote Continual Improvement	0.9	3.6	20.0	45.5	30.0
S10	Top Management drives relationships with all critical suppliers	0.0	6.1	18.3	43.5	32.2

S1: There has been a reduction in process wastage

The responses for statement S1 revealed that 41.6% of the respondents agreed that there was a reduction in wastage since the implementation of ISO 9001. The high level of agreement could have possibly been attributed to the standard's strong emphasis on process monitoring, process standardisation and continuous improvement, which according to Sa *et al.* (2022) results in minimising defects and reducing waste. On the other hand, the significant responses of neutral (32.7%) and disagreement (25.7%) may indicate that these respondents could not confirm that the reduction of waste was directly linked to the standard. These respondents could have attributed the reduction of waste in their organisations through other initiatives such as Lean manufacturing or other internal quality programmes. He (2022) highlights that ISO 9001 can help lower entropy through robust process monitoring controls.

S2: The business processes are clearly defined through process mapping

For statement S2, 74.5% of the respondents agreed that their business processes are clearly defined through process mapping. The high level of agreement is consistent with the requirement of ISO 9001 standard, which stipulates the necessity of having well documented and standardised processes. This is aligned with Omisola *et al.*

(2024) who reported that process mapping tools and standard operating procedures (SOPs) are commonly used within the ISO 9001 standard to document activities within an organisation. The 21.9% of respondents that remained neutral could mean that they are not sure if their processes are well defined, while the 3.5% of respondents that disagreed indicates that their processes are not clearly defined. This could possibly be a concern, as poorly defined processes could result in substandard quality as noted by Roopnarian *et al.* (2023).

S3: The business processes are analysed and engineered to remove non-value adding steps

Statement S3 shows that majority of the respondents (49.1%) agreed that their organisations have reviewed and analysed processes to eliminate steps that do not add value, while 40.4% remained neutral and 10.5% disagreed. These findings suggest that while some of the respondents recognise their efforts which are aligned with Lean thinking as a means to improve process efficiency, others are not sure if such measures are in place. According to Omisola *et al.* (2024), ISO 9001 promotes Lean thinking and continuous improvement as a means to enhance process efficiency and improve product quality. For those who disagreed, it could possibly mean that they may not fully be aware that ISO 9001 indirectly supports the concept of Lean thinking as applied in the context of continuous improvement. The importance of removing non-value-added steps is further exacerbated by He (2022), who indicates that this is a critical step in any business as it serves as a means to reduce entropy by eliminating disorder and inefficiency from processes.

S4: There have been significant changes to business processes

Statement S4 shows that 59.1% of respondents agree that the implementation of ISO 9001 led to significant changes in business processes. This suggests that many have observed meaningful adjustments, likely driven by ISO 9001's requirement to review, document, and improve existing processes to align with quality objectives and compliance (Chiarini and Cherrafi, 2023). However, the remaining 40%, who either disagreed or responded neutrally, may not have experienced or recognised major changes. This could be because their organisations already had mature systems in place before adopting ISO 9001, or the changes made were more incremental and less visible to staff. This also highlights that the impact of ISO 9001 implementation

can vary depending on how thoroughly an organisation embraces the process review and improvement elements of the standard. These results underscore the role of ISO 9001 in reducing organisational entropy through process change and control (Lollai, 2017).

S5: Routine formal quality management reviews lead to changes in business processes

In terms of statement S5, 60.2% of the respondents agreed that routine formal quality management reviews lead to improvements in business processes. This thus indicates a general perception that management reviews contribute to process optimisation and continuous improvement as identified by Limon-Romero *et al.* (2024). However, for the 32.7% of respondents that remained neutral and the 6.1% of respondents that disagreed, it could highlight some level of uncertainty and disagreement among the respondents as to whether the business processes are re-engineered to enhance the business. This may reflect a lack of visible outcomes from management review decisions, limited involvement of staff in process changes, or unclear communication on how review findings are translated into actionable improvements.

S6: Business data across the functional areas are collected and analysed for decision making

There is a 76.6% agreement among respondents for statement S6 that majority of the business decisions are made with business data. This supports the view that data plays an integral role in guiding organisational strategies and operations, as emphasised in the ISO 9001 standard's focus on evidence-based decision making (de Carvalho and de Medeiros, 2022). Data-driven decisions are key to controlling business entropy by reducing unpredictability and disorder in organisational processes (Markyna and Dyachkov, 2014).

S7: There is a strong emphasis on sustained continual improvement methodologies across all functional areas of the business

The high level of agreement (76.5%) for Statement S7 suggests that the respondents embrace the concept of continual improvement methodologies across all functional areas of their organisations. This aligns with Alshahrani and Husain (2024), who asserts ISO 9001 plays a key role in promoting a cultural shift towards the ongoing

adoption of improvement practices across all functions and processes within organisations. In addition, Sherwani (2025) points out that continuous improvement is not a one-time effort, but a core, ongoing component of business operations. The respondents that remained neutral could imply that they are unaware of continuous improvement activities taking place in their organisations, while those that disagreed could mean that they struggle to implement continuous improvement effectively or possibly fail to maintain focus on it consistently. According to Lollai (2017) continual improvement practices act as key mechanisms to combat the natural increase of entropy in businesses.

S8: Leadership provides resources for continual improvement

Statement S8 shows that 76.5% of the respondents agreed that resources are made available in support of continual improvement activities within their organisations. This thus reflects the recognition that sustained improvement is essential for maintaining competitiveness and reducing operational costs. According to Santos (2023), leadership commitment plays a critical role in ensuring the allocation of both financial and human resources necessary for driving ongoing improvement initiatives. The disagreement and neutral responses may arise from inconsistencies in how resources are allocated across departments, a lack of visibility of improvement efforts, or limited communication from leadership regarding support for such initiatives (de Carvalho and de Medeiros, 2022).

S9: Routine formal quality management reviews promote continual improvement

For statement S9, majority of the respondents agreed (75.5%) that the management review process within their organisations has a positive influence on continuous improvement. This result mirrors statement S8 which identified Leadership support in providing the necessary resources to drive continuous improvement. This is consistent with Manalansan (2022) who reported that management reviews serve as an important tool for identifying areas that requires improvement and to ensure that improvement initiatives are being monitored and supported. However, in terms of the respondents that remained unsure or disagreed it could possibly mean that they are not fully aware of the support mechanisms in place to drive continuous improvement in their organisations.

S10: Top management drives relationships with all critical suppliers

For statement S10, 75.7% of the respondents agreed that their top management plays an active role in managing relationships with critical suppliers. This is aligned with Luo *et al.* (2023) and Vanichchinchai (2022) who concur that strong supplier relations should start at the top, with the leadership actively playing a key role in encouraging collaboration and setting expectations on quality requirements. For the respondents that remained neutral it could possibly mean that they are unsure if their management team are actively involved with suppliers, while those that disagreed could imply that their supplier relationships are managed entirely by their operational procurement and logistics teams, without top leadership involvement. According to Durmaz *et al.* (2021), it is important for top management to be actively involved with supplier relationships, as it has a direct impact on external sources of entropy that enters an organisation.

Qualitative results

Question 1: To what extent have you recorded a reduction in wastage since ISO 9001?

The theme that arose for Question 1 was that there has been a measurable decrease in wastage since ISO 9001 was implemented. However, this reduction is mainly due to improvements in manufacturing processes, lean practices in production, and updated technology, rather than the certification itself. These qualitative insights triangulated with Statement S1 of the survey where majority of the respondents were either in agreement or neutral that ISO 9001 helps to reduce waste.

Question 2: To what extent has ISO 9001 triggered BPR?

In response to Interview Question 2, the participants generally indicated that ISO 9001 system requirements did not explicitly drive BPR. They reported little to no significant process redesign and noted that methodologies like Lean and Six Sigma were only minimally adopted, after the certification was implemented. This finding triangulated with the quantitative data from Statement S4, where some of the respondents did not acknowledge any noteworthy process engineering practices taking place in their organisations. Similarly, the responses to Statement S3 further support this finding, where 50.9% indicated disagreement and neutrality about their business processes being engineered to remove waste post ISO 9001 implementation. This suggests that

while ISO 9001 may enhance process standardisation and compliance (Sa *et al.*, 2022), it has not served as a catalyst for fundamental business process transformation in the sector.

Question 3: How does the formal quality management review add value to your business?

For Interview Question 3, the theme that arose was that the formal quality management review was a useful coordination tool rather than a driver of strategic transformation. While it facilitates cross-functional discussion and reviews of key metrics, its primary value lies in reinforcing existing processes, addressing operational risks, and ensuring alignment among the departments. These qualitative findings triangulated with statements S5 and S9 of the quantitative data, where a significant proportion of respondents agreed that management reviews support business changes and promote continual improvement. This is consistent with Roopnarian *et al.* (2023) that the formal quality management review process plays a central role in driving collaboration, decision-making, and sustained business improvement.

Question 4: Why do you feel that the ISO 9001 system supports your business objectives?

The main theme that emerged from interview question 4 was that the participants described ISO 9001 as a mechanism that ensures business and quality goals remain visible and measurable through integration into managerial key performance indicators. While these objectives are aligned with the broader organisational strategy, the system was primarily seen as a tool for reinforcing alignment and accountability through regular review and adjustment. The feedback was consistent with the survey findings for statement S6 which showed strong agreement among the respondents that business data, including data relating to business objectives, is analysed for business reporting. This alignment highlights ISO 9001's role in structuring quality practices and supporting the achievement of business objectives through data-driven management (Ivanov *et al.*, 2025).

Question 5: To what extent has ISO 9001 influenced continual improvement?

The main theme that developed from Interview Question 5 was that continual improvement is still not fully embedded as a proactive practice. The participants

indicated that ISO 9001 has influenced continual improvement primarily through reactive mechanisms, such as addressing customer complaints or findings from internal audits. These situations prompt corrective action and contribute to a culture of learning and refinement, though participants agreed that a more preventative, forward-thinking approach is still lacking. This triangulated strongly with the quantitative responses to Statement S7, where the respondents noted that their respective organisations are committed towards continual improvement efforts across all business processes. However, some participants clarified that these efforts are primarily reactive, which initiated in response to failures and leading to what was described as a “fire-fighting” approach. The resulting solutions were often viewed as unsustainable, and leadership consequently regarded the current continual improvement practices as largely reactive than proactive. These findings also support the feedback received for question 6 which focuses on the level of problem solving within the organisations. In addition, the findings also triangulated with the survey findings for statement S9 regarding the support mechanisms in place to drive continuous improvement.

Question 6: How effectively is the root cause analysis (RCA) philosophy underpinning the continual improvement strategy?

The emerging theme that arose from Question 6 was that RCA is not yet fully entrenched within the continual improvement strategy. The participants reported that focus was mainly on incremental improvements driven by Kaizen principles. The participants also indicated that combining BPR with lean manufacturing and Six Sigma principles could result in a paradigm shift in business performance, aligning with the perspective of Al-Anqoudi *et al.* (2021). These findings also aligned closely with responses to Interview Questions 2 and 5.

Question 7: How has management supported the ISO 9001 resource requirements?

The central theme from Question 7 was that management demonstrates support for ISO 9001 resource requirements. The participants indicated that funding for quality-related resources is typically approved when aligned with strategic business priorities or justified by technical requirements. This triangulated closely with the responses to statement S8, where respondents strongly agreed that leadership actively supports

the resource requirements necessary to achieve quality objectives and continual improvement, highlighting a clear alignment between leadership commitment and quality assurance efforts.

Question 8: How do you manage your critical suppliers?

The main theme from Question 8 highlighted the importance of supplier partnership management, with leadership emphasising the development of long-term relationships over short-term benefits. This correlated with the findings from statement S10 of the survey which showed that leadership plays an active role in supporting and sustaining strong supplier relationships. According to Vanichchinchai (2022), fostering collaborative and strategic supplier partnerships is essential for maintaining quality standards and supporting overall business success.

Question 9: How has the ISO 9001 certification enhanced your business?

The core theme that surfaced from Question 9 was that ISO 9001 contributed to significant improvements across various areas of the business. Some of the common improvements noted were the reduction in scrap, wastage and customer complaints, improved product and process quality, and increased productivity. This is consistent with Chiarini and Cherrafi (2023) who indicated that the ISO 9001 standard provides a structured approach towards improvements through the use of SOP's, documented processes and ongoing monitoring of performance indicators. The overall management feedback was that the ISO 9001 certification was not viewed as a compliance requirement only, but rather as a strategic business tool that aligns people, processes and products to continuously improve how the organisation performs. This concurs with Sa *et al.* (2022) who asserts that ISO 9001's emphasis on risk-based thinking and continual improvement encourages proactive identification and mitigation of potential issues so that it contributes to long term business sustainability.

SUMMARY OF KEY FINDINGS

The main finding that emerged was that the various improvements reported through ISO 9001 implementation indirectly supports effective business entropy management. Collectively, the drivers of these improvements signify a systematic approach to minimising entropy and enhancing organisational efficiency and resilience as emphasised by He (2022). However, the findings also indicate that while ISO 9001 is

effective in maintaining operational stability, it is not sufficient on its own to drive deep organisational transformation. Key components of transformative change, such as the removal of non-value-adding activities, adoption of Lean or Six Sigma methodologies, and systemic innovation, were either weakly supported or largely absent. Management review meetings, although useful in identifying problems and initiating changes, appeared limited in their long-term impact, with a significant portion of respondents expressing neutral views about their effectiveness. Continual improvement efforts were found to be reactive, often triggered by audits or complaints, rather than proactive systems designed to prevent disorder (Korablev *et al.*, 2018). Nonetheless, leadership engagement in quality management, especially in supplier relationships, reflects an attempt to extend control and reduce entropy across the broader value chain. Overall, while ISO 9001 contributes to entropy management by promoting operational discipline, it lacks the dynamism required to drive sustained transformation, suggesting a need for complementary frameworks that foster innovation and adaptability.

RECOMMENDATIONS

A key focal point emanating from the findings entails the integration of complimentary continuous improvement methodologies to drive organisational culture change that will promote the focus of reducing variation to drive lower levels of entropy (Korablev *et al.*, 2018; Solomon *et al.*, 2017). In addition, the following recommendations are suggested to support entropy reduction:

- **Adopt Complementary Continuous Improvement Frameworks** - Organisations should integrate methodologies such as Lean, Six Sigma, or Kaizen alongside ISO 9001 to go beyond procedural compliance and focus on value creation, waste elimination, and process innovation (Al-Anqoudi *et al.*, 2021).
- **Reframe Management Reviews as Strategic Tools** - Management review meetings should shift from being periodic compliance exercises to becoming strategic sessions that explore innovation opportunities, future trends, and proactive risk mitigation strategies. This would enhance their long-term impact and relevance.

- Promote a Culture of Proactive Innovation - Encourage a mindset that values proactive improvement over reactive fixes. Staff should be empowered and trained to identify inefficiencies and propose innovations, creating internal momentum for change rather than relying on external audits or customer complaints (Korablev *et al.*, 2018).
- Incorporate Entropy Metrics into Quality Reviews - Use the concept of entropy as a diagnostic tool by developing metrics to monitor disorder, inefficiencies, and system deterioration. This can help organisations recognise where ISO compliance may be masking deeper performance issues.
- Strengthen Cross-Functional Leadership Involvement - Expand the involvement of leadership beyond quality managers to include operations, R&D, and customer-facing functions. This cross-functional approach can help align quality goals with broader organisational transformation efforts.
- Enhance Supplier and Stakeholder Engagement - Move beyond transactional supplier relationships by incorporating shared quality objectives, collaborative problem solving, and performance-based partnerships. This reduces external entropy and builds resilience in the supply chain.
- Embed Quality into Strategic Planning - Position quality management as a central pillar of the organisation's strategic objectives. By aligning ISO 9001 processes with long-term business goals, companies can ensure that quality becomes a driver of transformation, not just a tool for order.

PROPOSED FRAMEWORK

The study proposes a business entropy management framework as depicted in Figure 1 based on the PDCA cycle and key entropy focus areas revolving around business scale, business complexity and business knowledge. Its operation relies on the integration of Lean, Six Sigma, BPR and integrated processes embedded into the PDCA cycle to systematically monitor, manage and reduce entropy within the business context.

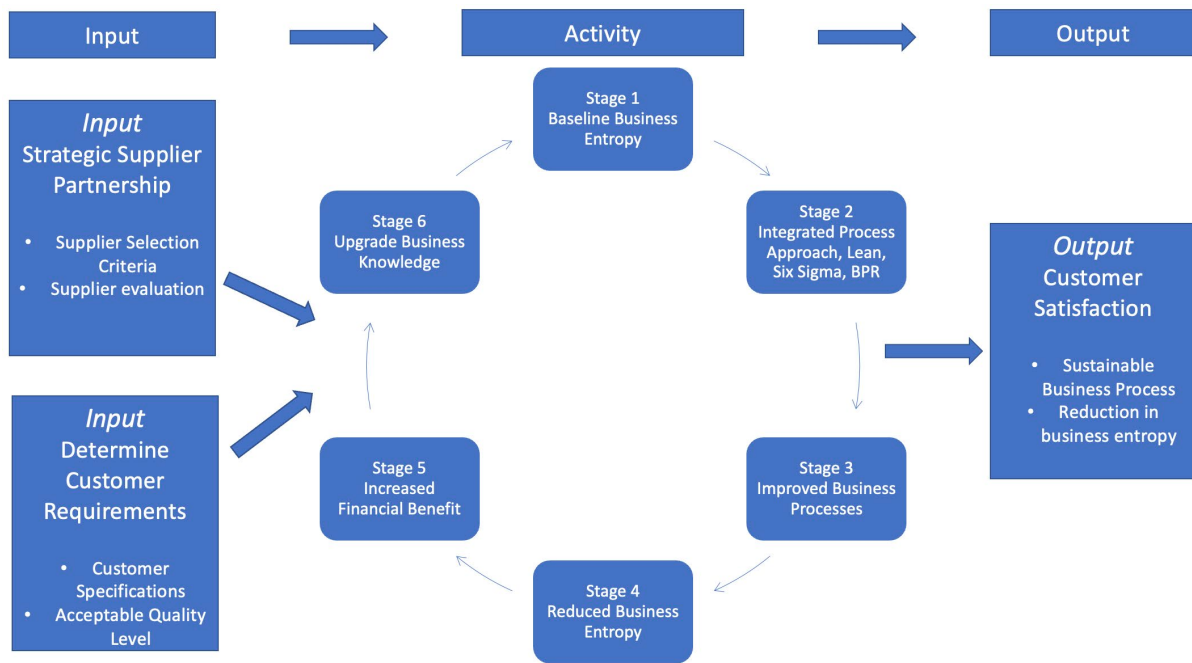


Figure 1 – Business entropy management framework

As can be seen in Figure 1, there are two input variables namely establishing strategic supplier partnership and understanding customer requirements that feed directly into the six-step operational cyclic process, with customer satisfaction as the output. The first input variable on strategic supplier partnerships must be reinforced through structured procurement policies, reduced lead times, lower inventory management, responsive distribution logistics, and improved forecasting systems (Luo *et al.*, 2023).

The second input variable of the framework is concerned with understanding the customer requirements and their long-term business plans from a strategic supplier partnership relationship perspective to drive the integrated process approach and enable greater focus on internal Lean, Six Sigma and BPR requirements. This rationale is underpinned by the logic that there can be no business strategy without knowing the customer's exact requirements.

The six-step operational cyclic process starts at stage one, where baseline business entropy measures such as process variation, production complexity, workforce knowledge and the maturity levels of the organisation are incorporated into a consistent measurement system. In step 2 of the cycle, the organisation must use value stream mapping to document and visualise all of its workflows to understand how the different processes interconnect and influence each other. This will also identify non-value adding activities and the quality requirements required for the input

of each process as it is received from the preceding process, thereby informing an interactive process management approach. At this stage, Lean and Six Sigma tools and techniques should be used to monitor the performance of the respective processes. Subsequently, a dedicated team should be used to identify BPR projects based on the level of inefficiencies and financial yield as identified through pareto analysis (Al-Anqoudi *et al.* 2021). These steps contribute to reduced business entropy as highlighted by He (2022).

The third step of the cycle entails measuring and monitoring the process sigma values from the targeted processes. Once these improvements have been acknowledged, it should be clearly communicated and celebrated throughout the organisation. In addition, training should be provided to sustain these improvements, and the lessons learned, and knowledge gained should be documented in a central database and transferred to other similar processes within the organisation.

Step 4 of the cycle requires the actual measurement of business entropy, which should be conducted after the successful implementation of steps 1 to 3. These entropic measurement indicators would have been identified in step 1. In step 5, after the entropy measurements have been established the financial value should be measured by the financial team. These savings must be communicated and celebrated throughout the organisation as a means to sustain the continuous improvement momentum and positive impact of reducing entropy across all processes.

Step 6 entails documenting the major business changes in the lessons learned database to reflect how the reduction in sigma values contributed to better system order. It should highlight the specific interventions implemented, their measurable impact on process stability, and how they influenced the overall organisational efficiency. Concurrently, targeted awareness campaigns of the major business changes should be implemented to reinforce organisational understanding on the importance of reducing variation, contributing to the reduction in overall business entropy. The last phase of the framework is the output stage which is customer satisfaction supported by sustainable business processes and lower levels of business entropy.

CONCLUSION

This study examined the intersection of the ISO 9001 standard and business entropy, and found that ISO 9001 provides structure and consistency to effectively reduce operational disorder through standardised processes and continuous improvement. However, it was established that continuous improvement efforts are treated reactively to problems as they occurred instead of pursuing proactive innovation and strategic responses needed for sustaining business vitality in the competitive environment. In addition, it was established that ISO 9001 on its own does not have all of the mechanisms to reduce entropy, and that other complimentary techniques such as Lean, Six Sigma and BPR is needed. The study highlights the importance of incorporating entropy measures into management reviews as a means to identify finer process variations and disorder that may not be captured by normal quality and performance indicators.

The study proposes a business entropy management framework that integrates Lean, Six Sigma and BPR techniques together with entropy based measurements into the PDCA cycle as represented in the ISO 9001 standard to more effectively monitor and manage organisational disorder. Future research should focus on further developing integrated entropy measurement tools as a means to provide quantifiable indicators of organisational disorder so that managers can make data driven decisions to proactively improve processes. In addition, future studies should explore how digital technologies such as artificial intelligence and machine learning can be incorporated into entropy management to enable real time monitoring.

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