Critical factors for the implementation of integrated management systems: an analysis using AHP

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Abstract. To achieve excellence in the management model, while fulfilling stakeholders' requirements and customers' expectations, is among the challenges faced by companies. The implementation, evaluation, and maintenance of an integrated management system (IMS) is a common practice in companies of different sizes and from different industrial sectors to meet these challenges. This is why studying the critical factors for implementing an IMS successfully is relevant. The objective of this paper is to identify and classify critical factors for the implementation of an IMS, using the analytic hierarchy process (AHP). Ten critical factors were identified in the literature and classified by experts, who carried out a pairwise comparison. Among the experts consulted, 60% are industry professionals and 40% are professors at higher education institutions. The results indicate the degree of importance of each critical factor identified, with top management commitment as the most critical factor considered for implementing an IMS.

Keywords: Integrated management system, Implementation, Critical factors, Analytic hierarchy process.

1 Introduction

In the organizational context, achieving excellence in the management model is one of the main challenges of companies. The requirements of stakeholders enforce companies to get certifications that assure the fulfillment of customer expectations. The implementation, evaluation, and maintenance of an integrated management system (IMS) is a common practice in companies of different sizes and from different industrial sectors to meet this objective [1].

An IMS integrates the various processes of a company, including, e.g., the processes of a quality management system (QMS), environmental management system (EMS), occupational health and safety management system, and social responsibility management system.

Studying the implementation process of the international standards that establish the requirements for management systems is essential for companies that aim to get

certificated. This matter is also of interest to companies already certified, which may be able to anticipate problems in case of a maintenance audit or certification renewal.

Even though the relevance of this subject for companies, there are few studies on the implementation of IMSs [2, 3]. Therefore, this paper intends to identify and classify critical factors for the implementation of an IMS. The results are expected to contribute to the development of this field of research and to provide insights to companies regarding the implementation process of IMSs.

To achieve this objective, first, the possible critical factors for the implementation of an IMS are identified based on the literature. These factors are then analyzed by experts, ranking their relative importance through the analytical hierarchy process (AHP).

The AHP is a method to support complex decisions, which provides a rational procedure to structure, represent, and quantify the elements of a problem, relating them to global goals, and evaluating alternative solutions [4].

This paper is structured as follows. Section 2 presents the main critical factors identified in the literature. Section 3 describes the methodology adopted (case study) and the AHP. Section 4 reports the results, which are discussed in section 5. Finally, section 6 summarizes the conclusions of this work and presents its limitations as well as opportunities for future studies.

2 Critical factors for the implementation of integrated management systems

Management systems integration combines the functions of two or more systems into an effective multifunctional system with dynamic benefits. There are barriers that hinder this integration and, consequently, the effective implementation of an IMS. These barriers can make the process confusing, demotivate workers and affect system performance, leaving it below ideal performance [5]

Determining the critical factors for the implementation of an IMS allows companies to visualize which are the essential processes for the proper functioning of the business. Thus, the company can focus on solutions and prioritize investments in areas that need more attention.

Identifying the critical factors for the implementation of an IMS means generating strategic information that supports the decision-making process. Thus, the IMS represents an important tool for management [6].

Critical factors for the implementation of management systems have been studied recently. Almeida, Muniz Jr and Pradhan [2] analyzed the implementation of ISO 9001:2015 in an automotive industry, using AHP to identify the critical factors of implementing a QMS successfully.

The critical factors identified and classified by the experts were: top management commitment, team commitment, quality culture, responsibilities and authorities, training, integration between departments, resources availability, schedule, quality team reliability, non-bureaucratic management system, process approach, measurement system analysis and awareness of the importance of ISO 9001.

Ikram, Sroufe and Zhang [3] identified 26 barriers to the implementation of an IMS, which were classified using AHP. These barriers were split in 6 main criteria: resources and management, people, implementation, economy, social and legal, and cultural.

The critical factors and barriers identified by previous studies can be considered critical factors for the implementation of an IMS. Thus, the 36 critical factors were listed and analyzed, identifying duplicate, similar or overlapping factors.

The critical factors identified by Almeida, Muniz Jr and Pradhan [2] are more comprehensive and include the barriers identified by Ikram, Sroufe and Zhang [3]. Therefore, this study considers the 10 critical factors identified by Almeida, Muniz Jr and Pradhan [2] and lists the 26 sub-criteria presented by Ikram, Sroufe and Zhang [3] in the description of their respective factors.

Table 1 summarizes the critical factors and their description.

Table 1. Critical factors for the implementation of an IMS.

Item	Critical factor	Description
1	Top management commitment	Top management prioritizes the implementation of the IMS, providing support, guidance, monitoring and promoting the required support.
2	Team commitment	The team is involved with the implementation of the IMS, committed to achieving the objectives defined by senior management. Workers are motivated, with the right attitude and perception, working as a team and open to changes.
3	Training	Training focused on quality and environmental management, to level knowledge. Appropriate audit methodology and specialized auditors.
4	Responsibilities and authorities	Clear definition of the responsibilities and authorities of each worker, ensuring the team commitment regarding their attributions. It allows team's flexibility and establish well-defined stakeholder demands.
5	Schedule	Schedule for implementation of the IMS, defining actions, responsibilities, and deadlines. It provides a strategic planning for deployment with time availability and on time deliveries.
6	Culture for quality and environmental management	The company must have a culture of quality and the environment widespread among workers.
7	Resources availability	Allocation of financial and human resources to ensure the implementation plan. The company provides managerial and administrative support, offering the necessary benefits.
8	Integration between departments	There are no barriers to cross-departmental support. Workers are integrated and aware of their responsibilities, regardless of differences in cultures and personalities.
9	Non-bureaucratic management system	Management systems without bureaucracy that prevent the development and implementation of actions. The team

Item	Critical factor	Description
		understand the approach of each management system and the need to adapt to changing standards.
10	Awareness of the importance of the IMS	Workers value the IMS and know its importance to the company and the benefits it provides.

3 Methodology

To evaluate the critical factors for the implementation of an IMS, two steps were followed: 1) the identification of critical factors in the literature and 2) the classification of these factors using the AHP. The use of AHP in assessing factors for the management of IMSs is recognized as a research opportunity [7].

Ten critical factors for an IMS implementation were identified: top management commitment, team commitment, training, responsibilities and authorities, schedule, culture for quality and environmental management, resources availability, integration between departments, non-bureaucratic management system, and awareness of the importance of the IMS.

The AHP was chosen to develop the second step, as it consists of a multicriteria decision method to solve complex problems that can be decomposed in subproblems with hierarchical levels. Each hierarchical level represents a set of attributes or alternatives related to each subproblem, and the highest level of the hierarchy represents the objective of the problem. For this study, the objective is the effective implementation of an IMS. In addition, AHP is considered an effective decision support method, capable of reducing complex decisions in a pairwise comparison [4].

The AHP has been used in several domains, to structure and organize managers judgments so that they can make more assertive decisions. Although the AHP has a simple application, its theoretical basis relies on concepts of matrix calculation and statistical analysis [8].

The main advantage of AHP is that it allows the user to assign relative weights to multiple criteria in an intuitive way, while performing a pairwise comparison. This means that, even when two criteria are incomparable, it is possible to recognize which of the criteria is more important based on the knowledge and experience of specialists [4].

On the other hand, applying the AHP based on expert contributions requires time to complete all pairwise comparisons (e.g., a structure with 10 factors requires 45 comparisons) and the high number of comparisons can impact the response rate negatively [2].

To collect the experts' opinions, an Excel file was developed and distributed electronically via email. The experts compared the criteria based on their perception of importance towards the implementation of an IMS. In total, the file was distributed to 20 specialists, who work in extractive industries, wholesale trade and commission trade, except of motor vehicles and motorcycles, companies providing engineering services or higher education institutions.

Respondents were selected according to their professional or academic experience.

After identifying the critical factors for implementing an IMS, a matrix of priorities and criteria must be constructed, to compare the factors, pair by pair.

Whether the factors compared are equal in importance, the value 1 is assigned; whether factor 1 is slightly more important than factor 2, the value 3 is assigned; whether factor 1 is much more important than factor 2, the value 5 is assigned; whether factor 1 is clearly or very strongly more important than factor 2, the value 7 is assigned; whether factor 1 is absolutely more important than factor 2, the value 9 is assigned.

Any intermediate relationship must be given the corresponding intermediate value. An element is equally important when compared to itself. This means that the main diagonal of the priorities and criteria matrix is 1. Finally, when comparing factors 2 and 1, the values entered in the matrix must be the appropriate reciprocals (1, 1/3, 1/5, 1/7 or 1/9) [4].

Pairwise comparisons are used to model the mutual interaction between factors and then measure and rank their system-wide impacts. The result of the comparisons is the relative order of importance between the factors. Finally, experts' opinions are unified, and the final weight of the factors evaluated is obtained by calculating the geometric mean [4]. The AHP output is a global priority indicator [2].

4 Results

From the distribution of the Excel file to the 20 experts, 10 useful responses were received, representing a response rate of 50%. Among the respondents, 60% are industry professionals and 40% are professors at higher education institutions. Among professionals, 67% work in companies in the wholesale trade and commission trade, except of motor vehicles and motorcycles, 17% belong to companies providing engineering services and 16% work in extractive industries.

A numeric scale from 1 to 9 was used to reflect the preferences between criteria and to construct the judgment matrix, which was normalized to calculate the relative weights. Then, the normalized eigenvector corresponding to the largest eigenvalue of the judgment matrix was calculated. This vector contains the relative weights of the criteria.

To check the consistency of the judgment matrix, the consistency index (CI) was calculated according to equation 1, where λ_{max} is the largest eigenvalue of the judgment matrix; and *n* is the number of criteria being evaluated.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (1)$$

After that, the CI was compared to the random consistency index (RI), which is a reference to evaluate the consistency of the matrix. The RI value depends on the dimension of the matrix and can be calculated as stated in equation 2, where *CI* is the consistency index, that varies according to the consistency level desired. Usually, a consistency level of 0.1 is acceptable.

$$RI = \frac{CI-n}{n-1} \quad (2)$$

The consistency ratio (CR) was used to calculate the degree of consistency of the judgment matrix. The CR is calculated as described in equation 3. The CR must be less than or equal to 0.1 for the matrix to be considered consistent.

$$CR = \frac{CI}{RI} \quad (3)$$

The relative weights of the criteria are calculated by dividing each element of the normalized eigenvector by the sum of all elements of the vector, according to the equation 4, where w_i is the relative weight of the alternative or criterion i; v_i is the corresponding element of the normalized eigenvector; and $\sum v$ is the sum of all elements of the normalized eigenvector.

$$w_i = \frac{v_i}{\sum v} \quad (4)$$

The results are described in Table 2.

Table 2. Weights assigned by the experts to the critical factors for implementing an IMS.

Critical factors	Experts									
	1	2	3	4	5	6	7	8	9	10
Top management commitment	0.127	0.264	0.395	0.156	0.166	0.306	0.232	0.274	0.243	0.282
Team commitment	0.074	0.131	0.120	0.127	0.055	0.105	0.089	0.096	0.195	0.204
Training	0.118	0.117	0.093	0.038	0.127	0.047	0.115	0.045	0.126	0.146
Responsibilities and authorities	0.056	0.111	0.059	0.109	0.123	0.168	0.056	0.050	0.152	0.113
Schedule	0.028	0.084	0.038	0.019	0.130	0.020	0.073	0.032	0.022	0.072
Culture for quality and environmental management	0.040	0.070	0.061	0.150	0.027	0.109	0.179	0.184	0.093	0.059
Resources availability	0.258	0.098	0.065	0.136	0.291	0.071	0.090	0.034	0.055	0.048
Integration between departments	0.036	0.040	0.070	0.129	0.024	0.030	0.065	0.040	0.036	0.030
Non-bureaucratic management system	0.145	0.035	0.052	0.053	0.012	0.066	0.025	0.086	0.016	0.033
Awareness of the importance of the IMS	0.118	0.051	0.049	0.085	0.044	0.077	0.077	0.158	0.062	0.012
Consistency ratio	0.094	0.066	0.177	0.096	0.087	0.088	0.184	0.104	0.204	0.435

The global priority indicator (GPI) is a measure used to assess the global priority of a criterion in relation to the other elements of the evaluated set. To calculate the GPI,

the relative weights of each criterion were multiplied by the corresponding value in the judgment matrix, then these values were added for each row of the matrix. This result is the GPI of the corresponding criteria.

The formula to calculate the GPI of a criterion i is given by equation 5, where w_{ij} is the relative weight of criterion i; a_{ij} is the corresponding value in the pairwise judgment matrix for the comparison between alternatives $_i$ and $_j$.

$$GPI_i = \sum w_{ik} a_{ij} \qquad (5)$$

The GPI is useful for evaluating the relative importance of each criterion in a broader context, considering the experts' preferences and the interactions between the elements evaluated. It can be used to rank the criteria in order of priority or to identify the criterion with the greatest global impact in relation to the others [4].

Table 3 shows the GPI, sorted in descending order.

Table 3. Global priority indicators of the critical factors for implementing an IMS.

Critical factors	General results Complete sample (10 answers)		Sensitivity analysis Complete sample, removing factor 1		Industry professionals (6 answers)		Academics (4 answers)	
	GPI (%)	Ranking	GPI (%)	Ranking	GPI (%)	Ranking	GPI (%)	Ranking
Top management commitment	23.23	1º	-	-	22.95	1º	23.65	1º
Team commitment	11.12	2º	15.48	1º	12.20	2º	9.69	4º
Responsibilities and authorities	9.12	3º	12.29	2º	8.18	5º	10.74	3º
Resources availability	9.06	4º	12.14	3º	7.67	6º	11.63	2º
Training	8.80	5º	10.82	4º	10,47	3º	6.78	6º
Culture for quality and environmental management	8.19	6º	10.81	5º	8.93	4º	7.20	5º
Awareness of the importance of the IMS	6.15	7º	8.02	6º	6.16	7º	6.13	7º
Integration between departments	4.39	8º	5.81	7º	3.99	10º	5.05	8º
Schedule	4.18	9º	5.44	8º	4.54	8º	3.70	10º

Critical factors	General results Complete sample (10 answers)		Sensitivity analysis Complete sample, removing factor 1		Industry professionals (6 answers)		Academics (4 answers)	
	GPI (%)	Ranking	GPI (%)	Ranking	GPI (%)	Ranking	GPI (%)	Ranking
Non-bureaucratic management system	4.07	10º	5.17	9º	4.23	9º	3.84	9º

5 Discussion

Global priority results indicate that top management commitment was the highest priority factor based on peer comparisons. This conclusion is consistent with previous studies that claim that this factor is essential for a successful implementation of IMSs.

This is because whether top management is committed during the implementation process, commitment from other stakeholders can be achieved and maintained. If top managers prioritize the implementation of an IMS, they will likely provide the support required for the process. Without the commitment of top management, the implementation of an IMS will probably fail [2].

A sensitivity analysis was performed to assess how the other factors rank when top management commitment is removed from the list. When the weight of a criterion changes, a change in the other weights is sought while investigating any influences on the final decision [3]. The results are shown in Table 3.

Disregarding the top management commitment, the order of priority of the other critical factors for implementing an IMS remains. In this case, team commitment became the highest priority factor for a successful implementation. This means that both top management and workers need to be committed to ensure that actions related to the IMS at the operational level occur as planned. In fact, team commitment is directly related to the climate of trust in the company, and IMSs implementations work best when there is a high perception of inclusion [9].

Therefore, it is essential to give workers access to decision-making processes during the implementation of an IMS to gain adherence to the process and obtain satisfactory results.

Furthermore, it is observed that the gap between the overall priority indicator of team commitment and the other critical factors is not as large as the gap between team commitment and top management commitment. This indicates that the lower ranking factors have approximately equal relative importance in the implementation of an IMS.

Thus, it is also important to define the responsibilities and authorities of each worker clearly to ensure the and involvement of the team. It is necessary to allocate financial and human resources to achieve the goals and ensure the implementation

plan. Training focused on the IMS processes should be provided to workers to level knowledge within the company. Furthermore, it is important to spread an organizational culture focused on integrated management among workers, to facilitate the implementation and acceptance of the IMS.

Factors with lesser importance also deserve attention, i.e., workers' awareness of the importance of the IMS; integration between departments (eliminating barriers between them), the establishment of a schedule for implementation and a management system with a low level of bureaucracy.

When the critical factors are analyzed according to the sector in which the respondent work, it can be concluded that, for both industrial professionals and professors, the commitment of top management is indicated as the most critical factor for the successful implementation of an IMS.

For professionals, team commitment is the second critical factor for implementing an IMS, while for professors is the resources availability. This difference may happen because resources availability is considered an internal barrier to the implementation of an IMS. This is because companies may not be able to include all management systems in their IMS and, therefore, must consider resource limitations in the implementation process [10].

Then, training, culture for quality and environmental management, responsibilities and authorities, and resources availability were classified in the third, fourth, fifth and sixth position by professionals, respectively. In these same positions, professors classified the factors of responsibilities and authorities, team commitment, culture for quality and environmental management, and training, respectively. These different perceptions may be related to the respondent' knowledge and experience.

Although workers' awareness of the importance of an IMS is directly related to the organizational culture and that an inadequate perception of the importance of an IMS is an obstacle to a successful implementation [11], both agree that this is not among the most critical factors for the implementation of an IMS, occupying the seventh position in the ranking.

Finally, for professionals, integration between departments is the least critical factor. This may mean that the implementation of an IMS can happen independently of the integration between departments. Therefore, future studies may consider this issue and explore this relationship with the aim of confirming this result.

On the other hand, for professors, establishing a schedule for implementation is the least critical factor. This is against previous research that states that defining an implementation schedule contributes to mitigating the difficulties and efforts related to the implementation process of an IMS [2].

6 Conclusion

This paper identified and classified the critical factors for the implementation of an IMS. Ten critical factors for implementing an IMS were identified in the literature: top management commitment, team commitment, training, responsibilities and authorities, schedule; culture for quality and environmental management, resources

availability, integration between departments, non-bureaucratic management system, and awareness of the importance of an IMS.

The AHP was chosen to classify the critical factors identified, as it is considered an effective decision support method, capable of reducing complex decisions in a pairwise comparison.

However, the AHP has limitations, e.g., it does not consider the uncertainty associated with the judgment and the selection, and preference of respondents are subjective, influencing the results of the analysis significantly. Also, the number of responses obtained is small, which may compromise the generalization of the results.

The results indicate that top management commitment is the most critical factor for the implementation of an IMS, according to the opinion of experts, who belong to extractive industries and wholesale trade and commission trade, except of motor vehicles and motorcycles, companies providing engineering services or higher education institutions. However, factors with lesser relative importance should not be neglected, as there is a risk that the implementation will not be effective.

This study has theoretical and practical implications. It contributes to the development of the literature related to the use of AHP in the assessment of factors for the management of IMSs and provides relevant information to direct the implementation process of an IMS in companies.

Finally, future investigations may consider deepening the studies in extractive industries, wholesale trade and commission trade, and engineering service providers to verify the importance of integration between departments. Additional research can explore the key factors that determine top management levels and team commitment. It is also recommended to consult experts from other industrial sectors, to increase the sample and confirm the results.

References

1. ASANO, B.S.; BOARIN PINTO S.H.; HORTELÃ M.F.; RIBEIRO L.G.N. Gestão da Qualidade e do Meio Ambiente: estudo de caso em um fabricante de filtros cerâmicos para a indústria de fundição. In: 64° Congresso Brasileiro de Cerâmica (2020).
2. ALMEIDA D.; MUNIZ JR. J.; PRADHAN N. Assessment of ISO 9001:2015 implementation factors based on AHP: Case study in Brazilian automotive sector. International Journal of Quality & Reliability Management, 35 (7), 1343-1359 (2018).
3. IKRAM, M.; SROUFE, R.; ZHANG, Q. Prioritizing and overcoming barriers to integrated management system (IMS) implementation using AHP and G-TOPSIS. Journal of Cleaner Production, 254, 120121 (2020).
4. SAATY, T. Método de análise hierárquica. São Paulo: McGraw-Hill (1991).
5. ASIF, M.; SEARCY, C.; ZUTSHI, A.; FISSCHER, O.A.M. An integrated management systems approach to corporate social responsibility. Journal of Cleaner Production, 56, 7-17 (2013).
6. COLAUTO, R.D.; GONÇALVES, C.M.; BEUREN, I.M.; SANTOS, N.D. Os fatores críticos de sucesso como suporte ao sistema de inteligência competitiva: o caso de uma empresa brasileira. Revista de Administração Mackenzie, 5(2), 119-146 (2004).

7. RAMANATHAN, R., SUBRAMANIAN, N. A review of applications of analytic hierarchy process in operations management. International Journal of Production Economics, 138(2), 215-241 (2012).
8. PERRIN, R. Real world project management: beyond conventional wisdom, best practices and project methodologies. John Wiley & Sons (2008).
9. BRAVI, L.; MURMURA, F. Evidences about ISO 9001: 2015 and ISO 9004: 2018 implementation in different-size organisations. Total Quality Management & Business Excellence, 1-21 (2021).
10. IRFAN, M.; ELAVARASAN, R.M.; AHMAD, M.; MOHSIN, M.; DAGAR, V.; HAO, Y. Prioritizing and overcoming biomass energy barriers: application of AHP and G-TOPSIS approaches. Technological Forecasting and Social Change, 177, 121524 (2022).
11. MUNIZ JR, J.; WINTERSBERGER, D.; HONG, J.L.F. Worker and manager judgments about factors that facilitate knowledge-sharing: Insights from a Brazilian automotive assembly line. Knowledge and Process Management, 29(2), 132-146 (2022).