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Integrated Management Systems: A statistical analysis

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ABSTRACT: Designing a maturity model is a multi—methodological task. Maturity modelling had been reported in several research areas, namely, software development and inspection, e-Governance, knowledge management, networkability, health and safety enterprise culture, supplier relationship, project management, communicational levels on collaborative activities and management systems assessment. The present paper aims to report the efforts being made focusing the development of an integrated management system (IMS) maturity and efficiency assessment tool. It presents a survey statistical analysis, which is a methodology emphasized by several authors when developing a maturity model. The most appealing statistical conclusions, based on a survey focusing Portuguese IMS ruled companies, are now reported answering several questions, such as: Do initial IMS implementation motivation relates with the final achieved benefits? Do sub-systems standards integration relates to the integration level achieved? Which are the success factors to consider in order achieving a successful and high-level integration?

1 INTRODUCTION

1.1 *An IMS maturity model development*

Systems integration ranges from technical to organizational disciplines. Organizational management systems integration, outputting an integrated management system (IMS), should take into account several external features as macroergonomics and sustainable development. Internal cultural features, like corporate social responsibility, and proactive ones, like life cycle assessment, should be considered too (Domingues *et al.*, 2012c).

On the present project, two surveys have been carried out: the first one focusing organizations and the second one focusing an experts group. Domingues *et al.*, (2012a,b,c) reported results based on the first survey and based on both surveys (Domingues *et al.*, 2012b).

Koshgoftar and Gosman (2009), concerning the importance of organizational maturity models, stated that it allows the weaknesses and strengths identification of the organizational system were applied and, through benchmarking related methodologies, the information collection aiming an upper maturity level. Maturity models had been criticized too due to some shortcomings, namely, lack of empirical foundations, reality oversimplification and data reliability on its design process (Jia *et al.*, 2011). Becker *et al.*, (2009) defined the main features to be considered prior to the development of a generic maturity model:

- Comparison with existing maturity models.
- Iterative procedure.
- Evaluation/assessment.
- Procedure sustained on a multiplicity of methodologies.
- Accurate problem identification.
- Results focused on the model dominium and on the users needs.
- Scientific documentation/methodologies sustaining the model development.

Taking into account this last item one may consider statistical analysis as an appropriate methodology to sustain the model development. Several authors had proposed this methodology when developing maturity models (Alessi, 2002) and the current paper intends to fulfil that assumption.

1.2 *State-of-the art*

The state-of-the art regarding IMS and maturity models has been reported in several previous publications (Sampaio *et al.*, 2012). Literature review regarding IMS implementation identified several features: motivation, obstacles, benefits, integration strategies, integration levels and audit typology.

Literature review regarding maturity models identified the following features: models typology and characteristics, application, evolution and maturity levels. This review, which was performed before the model development allowed the definition of the surveys carried out.

This paper is structured as follows: in section 2 the research methodologies adopted are described; section 3 presents the surveyed companies characterization and results derived from statistical analysis; section 4 discuss the available results. Finally, the paper presents the main conclusions answering several questions related to IMS ruled companies.

2 MATERIALS AND METHODS

A 30 Question/Statement (Q/St) online survey was carried out focusing on Portuguese organizations with more than one certified management subsystem according to the following standards: ISO 9001, ISO 14001 and OHSAS 18001/NP 4397. The survey was conceptually supported on a Likert type scale, for categorical and multiple option answers, being its structure reported in the appendix section (Table A1). The Q/St's were developed based on a deep bibliographic review and interviews with management systems managers.

A pre-test performed on three companies was used to validate the survey due to the reported limitations of using online surveys, such as sampling, representativeness, selection bias and response rate issues (Matsuo *et al*., 2004; Sackmary, 2012). The pre-test allowed also the refinement of Q/St's and answers scales minimizing the shortcomings when using Likert type scales which include the discrete nature of answers and the usual tendency for respondents for option the extreme values from the scale (Albaum, 1997; Clason and Dormody, 1994; Jamieson, 2004).

The following assumptions are supported on 53 valid answers given by the management systems manager during the period between 01–07–2011 and 01–11–2011. The response rate was of 15%. Statistical data analysis was performed with Portable IBM SPSS Statistics v19. String to numerical scale variable transformation was performed on St5 to St20, Q21, Q23, Q25 and Q28 to Q30.

Descriptive statistics, Kolmogorov-Smirnov with Lilliefors correction, Shapiro-Wilk, Kruskal-Wallis tests and dimension reduction were the statistical approaches performed on results dataset.

3 RESULTS

3.1 *Sampled organizations characterization*

Mainly higher than 50 workers organizations, located at North, Centre and Lisbon regions of Portugal with a QMS *and* EMS *and* OHSMS typology answered the survey. Construction, water supply, transport and logistics and other services were the most reported activity sectors in the sampled organizations matching with those reported by Sampaio and Saraiva (2012). These authors reported that QMS, EMS *and* OHSMS was the most reported IMS typology among certified organizations closely followed by QMS *and* EMS.

Regarding organization size (number of employees), mainly large enterprises were the respondents, suggesting that the assumption of Coelho and Matias (2010) that SMEs (Small and Medium Enterprises) are less interested in systems integration maybe accurate.

3.2 *Organizations characterization parameters versus other surveyed parameters*

Based on available results, no validated statistical relationship was found between companies' characterization features (Q1–Q4) and the other surveyed parameters.

3.3 *Descriptive statistics*

Descriptive statistics (Q/St5-20) included Kolmogorov-Smirnov with Lilliefors correction and Shapiro-Wilk tests, Normal Q-Q plot and detrended Normal Q-Q plot graphics in order to normal distribution assessment. Despite the fact that N = 53 (> 50) the tested results set were found to be non-normal distributed. This preliminary analysis implied that further statistical analysis would be performed through non-parametric tests. Data normalization was an alternate methodology to data analysis but it results' robustness is not comparable to that achieved by non-parametric methodologies.

3.4 *One sample Kolmogorov-Smirnov (K-S)*

One sample K-S test was performed (α = 0,05) on St5–20, St21, Q23, Q25 and Q28–30 in order to normal distribution assessment according to Table 1. Despite the fact that the N = 53 (> 50) the tested results set were found to be non-normal distributed.

Table 1. K-S test hypothesis and decision criteria.

Normality test hypothesis	Decision criteria
H_0: Q/St result set $\cap N(\mu,\sigma)$	Accept H_0 if Sigma (p-value) > α = 0,05
H_a: Q/St result set do not $\cap N(\mu,\sigma)$	Reject H_0 and accept H_a if Sigma (p-value) ≤ α = 0,05

3.5 *Non-parametric Kruskal-Wallis test*

Non-parametric Kruskal-Wallis test hypothesis (Table 2) was performed between Q28↔Q30, Q23↔Q25, St21↔Q23, St6↔Q23 and Q/St 14↔Q/St 23 ($\alpha = 0,05$). For all the tests described, group number (k) was four, so Kruskal-Wallis test hypothesis presents a three-freedom degrees (k–1) *Chi-square* distribution, validating the asymptotic sigma. String to numerical scale variables allows comparison according to the ranked means.

3.6 *Dimension reduction and components identification*

Variable reduction was performed considering St5–St20 in order to determine the enveloped concept behind the surveyed items determining the small set of factors/components that represent as much information as the entire 15 variables. The calculations were performed aiming an optimization of Cronbach's alpha coefficient (Christmann and Van Aelst, 2006; Lopez, 2007; Peterson, 1994; Prelog *et al*, 2009; Santos, 1999; Shojima and Toyoda, 2002).

A preliminary rotated Varimax matrix identified four components among St5-St20 (Table 3).

The selection of items per components was performed considering the highest values from Table 3 and these are presented on Table 4. Considering table 4 results, component 3 was eliminated due to the scarce (2) items pertaining to.

A scale reliability analysis was performed per component considering only the items pertaining to each component. Table 5 presents the SPSS outputs considering component 1. A Cronbach's alpha coefficient of 0,852 was obtained when performing reliability analysis considering 6 items.

The same calculations were performed related to components two and four (not shown). Reliability statistics concerning the former component presented a Cronbach's alpha coefficient of 0,615 (4 items considered) and the reliability analysis concerning the latter component a Cronbach's alpha coefficient less than 0,5. Due to this fact component four was not considered.

Table 2. Non-parametric K-W test hypothesis and decision criteria.

K-W test hypothesis	Decision criteria
H_0: $M_{Q/St1} = M_{Q/St2} = \ldots = M_{Q/Stk}$	Accept H_0 if Sigma $> \alpha^*$
H_a: $M_{Q/Stk} \neq M_{Q/St1} = M_{Q/St2} \ldots = M_{Q/St(k-1)}$	Reject H_0 and accept H_a if Sigma $\leq \alpha^*$

* Sigma validation if k – 1 freedom degrees Chi-square distribution by Kruskal-Wallis statistics (≥ 3 (k) groups)

Table 3. Rotated component matrix (Varimax).

	Component			
Q/St	1	2	3	4
5	0,216	0,054	0,857	0,089
6	0,772	0,038	0,176	0,009
7	0,770	– 0,021	0,397	– 0,110
8	0,039	– 0,107	– 0,004	0,655
9	0,101	0,733	0,421	– 0,083
10	0,428	0,718	0,144	– 0,229
11	0,459	0,491	0,409	– 0,295
12	0,796	0,200	– 0,072	0,055
13	0,397	0,217	0,233	0,564
14	– 0,662	– 0,139	– 0,074	0,158
15	– 0,333	0,001	– 0,083	0,730
16	0,633	0,364	– 0,215	0,158
17	0,665	0,215	0,477	– 0,017
18	– 0,057	0,224	0,689	– 0,036
19	0,076	0,844	0,050	0,141
20	0,475	0,405	0,471	0,043

Table 4. Selection of items per component.

	Component			
Q/St	1	2	3	4
5	–	–	0,857	–
6	0,772	–	–	–
7	0,770	–	–	–
8	–	–	–	0,655
9	–	0,733	–	–
10	–	0,718	–	–
11	–	0,491	–	–
12	0,796	–	–	–
13	–	–	–	0,564
14	–	–	–	0,158
15	–	–	–	0,730
16	0,633	–	–	–
17	0,665	–	–	–
18	–	–	0,689	–
19	–	0,844	–	–
20	0,475	–	–	–

Table 5. Component 1—total statistics.

Q/St	Scale mean if item deleted	Scale variance if item deleted	Corrected item—Total correlation	Cronbach's alpha if item deleted
6	21,53	7,216	0,670	0,820
7	21,34	7,344	0,690	0,817
12	21,58	7,171	0,677	0,819
16	21,42	7,709	0,521	0,848
17	21,45	7,637	0,710	0,818
20	21,64	7,042	0,592	0,839

4 DISCUSSION

Regarding Q28↔Q30, SPSS outputs suggests enough evidence that motivation (internal, mainly internal, external or mainly external) do relate with benefits (internal, mainly internal, external or mainly external) achieved by IMS implementation. This relationship was predicted by Domingues *et al.*, (2012a), analysing results through an alternate methodology, concluding that IMS implementation motivation typology has a high probability to output the same benefits typology.

Regarding Q23↔Q25 SPSS outputs suggests enough evidence that the IMS organizational structure classification ((1- Documental/2- Management tools and 1)/3- Policies and objectives and 1) and 2)/Common organizational structure and 1), 2) and 3)) do relate with the management system manager perceived integration level (1- Minimum integration level/2- Low integration level/3- Medium integration level/4- High integration level/5- Total/Maximum integration level) achieved by IMS implementation.

Regarding St21↔Q23 SPSS outputs suggests no evidence that organizational structure IMS classification do relate with the perceived difficulty on integrating the management sub-systems standards. This result implies that a high or low achieved IMS integration level do not relates with the perceived difficulty on standards integration.

The organizational structure in an IMS context (Q23) had been tested too regarding St6 (Top management training) and St14 (Documental level integration). Results suggest that these features do relate with the IMS structure classification, reflecting they are required as success factors for a high-level integration achievement. Thus, top management training and not just a document-based integration, certainly among other features, guarantee a successful high integration level organization.

Dimension reduction and further analysis identified two valid components. Concerning the first valid component, we propose that the enveloped concept is: organizational awareness and monitoring. This concept is related to the six validated items (top management training, integrative concept taken into account, organizational interactions and IMS as an add value perceptions and integrated objectives promotion and application). These items would be difficult to identify in an organization without top management awareness and proper monitoring procedures.

Related to the second valid component we propose as the enveloped concept: organizational vision. Tools, methodologies and goals alignment, integrated management procedures and KPI's, OPI's and MPI's implementation are items revealing (top management) organizational vision.

5 CONCLUSIONS

There seems to be enough evidence that IMS organizational structural classification does relate with the perceived integration level achieved and that initial motivation typology does relate with benefits typology achieved by IMS implementation.

No statistical relationship evidence was found when comparing difficulties on sub-systems management standards integration and the organizational IMS structure achieved suggesting that is not due to standards features that a higher integration level may or not be achieved.

Top management training and not just a documental-based integration were identified as required success factors on IMS implementation.

Dimension reduction analysis identified two components enveloped in the Q/St answers provided: organizational awareness and monitoring and organizational vision, being these also, success factors for a well succeeded integration.

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APPENDIX

Table A1. Survey que

Q/St	
St1-The company mair activity is:	
Q2-How many worker the company?	
Q3-Where is geographi located the company	
St4-The management s is certified according following standards:	

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APPENDIX

Table A1. Survey questions/statements.

Q/St	Possible answers
St1-The company main activity is:	Unstructured
Q2-How many workers employ the company?	Unstructured
Q3-Where is geographically located the company?	North; Centre; Lisbon; Alentejo; Algarve; Madeira; Açores
St4-The management system is certified according the following standards:	ISO 9001 + ISO 14001; ISO 9001 + OHSAS 18001; ISO 14001 + OHSAS 18001; ISO 9001 + ISO14001 + OHSAS 18001; Other
St5-Quality, Environmental and Occupational Health and Safety policies are integrated.	Totally disagree; Disagree; Nor agree or disagree; Agree; Totally agree
St6-Training related to management systems integration had been provided to top management.	""
St7-Integration concept had been taken into account during IMS implementation.	""
St8-Management system is bureaucratized.	""
St9-The tools, methodologies and goals from each management sub-system are harmonized/aligned.	""
St10-Top management reveals integrated vision.	""
St11-Management procedures are integrated.	""
St12-Organizational interactions derived from IMS implementation are perceived by responsible and top management.	""
Q13-The implementation process was supported on a guideline or in a framework.	""
St14-Integration occurs at a documental level.	""
St15-Authority from Environmental and/or OHS responsible is residual.	""
St16-IMS is an add-value.	""
St17-Integrated objectives are defined.	""
St18-On the company organizational structure there is a clear responsible by the IMS.	""
St19-The company monitors their processes based on KPI's, MPI's and OPI's.	""
St20-The company promoted the implementation of integrated indicators.	""
Q21-How do you classify the integration level of sub-systems standards?	Very easy; Easy; Reasonable; Difficult; Very difficult
Q22-If the company did not had implemented an IMS the overall performance comparing with the actual reality would be:	Lower than the present status; Equal to the present status; Higher than the present status

Table A1. (Continued)

Q/St	Possible answers
Q23-How do you classify the management system integration level?	1-Documental/ 2-Management tools plus 1)/ 3-Policies and objectives plus 1) and 2)/ Common organizational structure plus 1), 2) and 3)
Q24-Audits performed to management sub-systems are?	Integrated; Simultaneous, Overlapped, Sequential
Q25-In a 1 to 5 scale how do you characterize the IMS?	1-Minimum integration level/ 2-Low integration level/ 3-Medium integration level/ 4-High integration level/ 5-Total/ Maximum integration level
Q26-The strategy followed during integration process was:	Sequential "All In"
Q27-Organizational items not susceptible of being integrated are identified?	Yes No
Q28-The main motivations to implement the IMS were.	Internal/ Mainly internal/ External/ Mainly external
Q29-The main benefits resulting from the integration of the management system were.	""
Q30-The main obstacles found during the implementation of the IMS were.	""

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