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An integrated assessment platform for sustainability performance in value networks: a proposal and first evidence from industry

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Abstract Nowadays, companies seek to improve their sustainable performance not only considering themselves as independent actors but also as part of value networks. This brings more complexity and different variables to the measurement of their behavior and achievements. This article proposes an integrated assessment platform for the measurement of sustainability performance in complex production value networks, which encompasses two different types of assessment: a maturity assessment for qualitative areas at network and company levels and a KPI-based assessment for the measurement of quantitative outcomes. This work has been initially tested during different stages of its development in two workshops with companies and the results proofed its adequacy for identifying potential areas of improvement by following a cause-effect reasoning among the areas of the maturity assessment and the quantitative outcomes. Thus, the integrated assessment platform could be an useful tool for continuous improvement within value networks.

1. Introduction

Research on sustainability in general and on sustainability performance in particular suffers from one major problem: sustainability as such cannot be measured in exact quantitative terms. It is impossible to tell whether an organization, a product, or a performed activity is sustainable or "sustainable enough". However, there are two leverage points that can be capitalized on:
1) while exact quantitative measurement is not possible, qualitative criteria can be used to assess whether the conditions for sustainable performance are given. That is, instead of looking at results based on scant data and unclear implications, it is possible to look at likely causes of sustainable performance.
2) while it is not possible to tell with any certainty whether or not an organization or an activity is sustainable, it might be possible to say whether a change is likely to improve the sustainability of that organization or activity.
Based on this reasoning, we have reviewed existing performance frameworks, guidelines, and standards with respect to usefulness for qualitative assessment of sustainability performance. This review included both general and sustainability-

related approaches. The paper in hand presents a summary of the development of a framework for sustainability performance measurement in networks that builds on existing concepts, which it amends and further develops.
This paper introduces distinctive features of an integrated assessment platform for sustainability performance in value networks. Concepts and theories at its background are initially reviewed (section 2). Then, a summary of key requirements and design choices, driving the construction of the platform, is provided (section 3). The assessment approaches adopted in the design of the integrated platform are eventually presented and first evidences from two workshops carried on with industrial companies (section 4 and 5), before the concluding remarks (section 6).

2. Background

The ideology, reasoning, and other background information highlighted in this section for the development of Sustainability Performance Framework is based on the work done within an European project (named shortly in the remainder as SustainValue) that closely explores the manufacturing sector for the purpose of developing novel and innovative solutions. The ideas captured and the results derived involved a thorough review of relevant theories and cases. This section summarizes the main theories behind the development of a procedure for assessment of sustainability considering not only the performance of a single company but also the performance of its value network, particularly focusing on: (i) the standards and guidelines for sustainability, and (ii) the types of rating scales usable for performance assessment models.

Sustainability Performance Framework – the principal features and attributes
There is a broad base of different frameworks and approaches to measure sustainability performance. We assert that all existing approaches suffer from one or several problems that reduce their relevance [1] [2]. One of the core problems is that most frameworks are focused on the organizations or even on tangible (i.e. quantitatively measurable) results of organizations. Joung et al. [3], for instance, provide an overview and a categorization of indicators from eleven different measurement frameworks. They consider an indicator relevant when it "*directly relates to a meaningful and purposeful aspect of sustainability per the manufacturing process under evaluation*". However, we think that it is not enough to look at indicators that are directly related to sustainability aspects, but rather it is necessary to consider indirect effects through causal chains as well. By the same token, organizations that wanted to improve the quality of their products would only increase the amount of indicators and the frequency of statistical measures, but also look at underlying causes of product quality, such as selection and training of suppliers, purchasing terms and conditions, worker qualification and satisfaction,

and remuneration incentives. Some popular performance frameworks embrace this idea and distinguish between causes and effects. Examples are EFQM: Enabler and Results [4], the standard ISO 14031: Management Performance Indicators and Operational Performance Indicators [5], and the Balanced Scorecard/Strategy Maps concept [6].

Based on this reasoning, and on Donabedian's [7] [8] three-fold division into structure, process, and outcome, Beer and Liyanage [9] have introduced a performance framework consisting of three dimensions: Network Conditions, Internal Performance Levers and Outcome (Triple Bottom Line Assessment).

Network Conditions represents the network perspective within the framework, and it considers the inclusion of value adding partners within a given manufacturing system, as well as its stakeholders. This dimension is crucial for performing a comprehensive sustainability assessment in value networks. The underlying assumption is that an organization may not be entirely free in its actions when it depends on a network for value creation – which is almost always the case in practice. Organizations do depend on their environment to a certain extent; the greater the dependence on the network – i.e., the greater the network's power over the individual organization – the more important it is to take into account this network influence for coherent performance assessment. The network aspect is novel and not part of any established performance framework. It is important to acknowledge that organizations do not necessarily "manage" their network but sometimes have to *cope* with it [10] [11] [12]. Yet, this aspect has been neglected in the performance management literature, resulting in incomplete analysis of cause and effect chains. Three areas are part of the network dimension: Objective Alignment, Capability Matching and Partnership Health.

Internal Performance Levers consider the internal factors (i.e. internal to a company) that have impact on sustainability performance. Five areas are included in this dimension: Organizational Culture, Performance Management System, Governance, Strategy and Business Model, and Product and Service development. Internal Performance Levers address aspects that are likely to change the sustainability performance of a firm to the better or to the worse. Metrics of this dimension would not directly relate to sustainability, but they set the course of the company and thus determine the sustainability outcome.

Lastly, the Triple Bottom Line (TBL) assessment represents metrics and indicators for sustainability performance concerning the sustainability dimensions: economic, environmental and social. This seems to be the area that has been developed furthest in research on sustainability performance.

Cause and effect relationships may be envisioned amongst the dimensions: while Network Conditions and Internal Performance Levers are representative of leading characters/attributes, TBL assessment consists of lagging characters/attributes. That is, what is measured in this last dimension can be understood as the result of measures taken within the previous two dimensions.

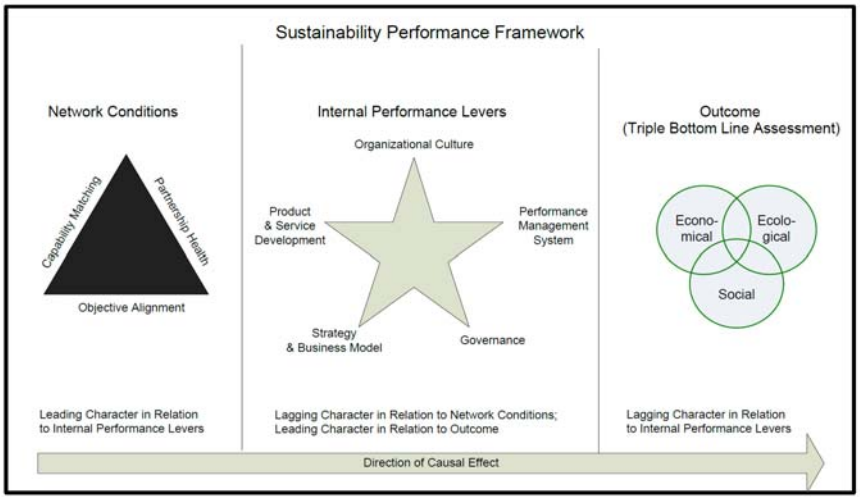

Fig.1 Sustainability Performance Framework in Value Networks (from [9])

Substantiating theoretical aspects – standards and guidelines

The most common standards and guidelines for sustainability, providing the correct background for the development of the platform, were selected from the following sources:

– ISO (International Standard Organizations), considering (i) the ISO 14000 family of voluntary standards and guidance documents to help organizations addressing environmental issues [13]; (ii) a specific ISO standard focused on the energy management system (ISO 50001) [14]; (iii) a specific ISO standard focused on the social responsibility (ISO 26000) [15];
– SA (Social Accountability International), for what concern a specific standard on the labour conditions in respect of social responsibility [16];
– EMAS (Eco-Management and audit scheme), published by the European Commission, as a management tool for evaluating, reporting and improving a company's environmental performances [17];
– GRI (Global Reporting Initiative) framework on Sustainability global economy, for measuring and reporting economic, environmental, social and governance performances [18].

Standards and guidelines for sustainability were especially helpful for identifying the adequate metrics/indicators to be employed for sustainability performance in value networks. For example, the GRI Sustainability Reporting Guidelines can be considered as the most comprehensive reporting framework up to date. These guidelines contain all three elements (environmental, economic, social) that make-up the TBL assessment of sustainable development.

Substantiating theoretical aspects – rating scales

Rating scales have been considered with the purpose to complement quantitative indicators with qualitative assessment of sustainability performance. Three different rating scales have been analysed.

– Binary Scales. Generally, binary scales can be of different character, i.e., nominal scales (e.g. assessment of gender; yes/no questions) or ordinal scales (e.g. assessment of age groups). Although they provide the property of dichotomous, their use for performance management is limited, as they do not point out the ways towards performance improvement. They can also tend to involve subjective assessment and freedom of interpretation, depending on how the questions are formulated [19].
– Likert Scales. They are ordinal scales and thus involve pre-defined ordering of the characteristics displayed. They include two extreme poles on each side of the scale and several intermediate levels in order of intensity or magnitude. As Moultrie et al. [19] point out, Likert scales provide a higher degree of information granularity but still do not provide much guidance for performance improvement.
– Maturity Models. Building on the general concept of Likert scale, maturity models provide anchor phrases and descriptions for each scale level. The advantage is that they provide richer information, on which the assessment can be based. Moreover, more comprehensive descriptions of scale levels provide better guidance for performance improvement. While maturity models are similar to Likert scale, they may in fact represent Guttman scales [20], where a lower level characteristic is always included in all higher levels, making them more suitable for performance assessment and improvement.

Maturity Models (MMs) are considered in the reminder as the rating method used to complement the TBL assessment, because of their potentials of performance improvement.

Substantiating theoretical aspects – maturity models

MMs can be defined as staged roadmaps for assessing the capabilities of a company/organization with respect to a specific management domain [21]. According to Röglinger et al. [22], MMs normally include a sequence of levels (or stages) that form an anticipated, desired, or logical path from an initial state to maturity. Their basic rationale is to outline the stages of maturation paths and they can serve concretely for descriptive (assessing as-is situations), prescriptive (identifying desirable future maturity levels) and comparative (allowing both internal and external benchmarking) purposes [22].

The Capability Maturity Model Integration (CMMI) is a MM deriving from the Capability Maturity Model (CMM) introduced by Paulk et al. [23]. CMM bases on the idea that improvement is done by little steps rather than by radical changes, by focusing on some process areas and by adopting some key practices therein [24].

The CMMI is a de facto standard, originally proposed for the maturity assessment in the software engineering domain, soon applied to many other application domains in business (such as project management or supply chain management).

According to the definition given by Paulk et al. [23]: "*A maturity level is a well-defined evolutionary plateau towards achieving mature processes. Each maturity level provides a layer in the foundation for continuous process improvement (…) Achieving each level of the maturity framework establishes a different component in the 'construction' process, resulting in an increase in the process capability of the organization*". Following this definition the maturity (capability) levels goes from a low level, representing unorganized processes, to the highest level, representing a proactive attitude based on a continuous improvement approach.
Different examples of scales already proposed in literature regarding maturity and capability levels are now emergent in many fields of application, different from the original of CMM/CMMI methodology (e.g. to measure the capability levels in a service organization [25]; to measure the capability levels in maintenance management [24]).

3. Design choices for integrated assessment platform

Designing an integrated platform for sustainable performance excellence involves two important elements that are mutually reinforcing, namely requirements and choices. This section brings those two elements to the spotlight that provided the basis for the integrated assessment platform.

Key requirements for the integrated assessment platform

The first requirement concerns the support of a comprehensive assessment of the value network's effectiveness. The three-fold approach suggested by Donabedian [7] [8] (i.e. structure, process and outcome), has been considered as a source of inspiration to this end, where structure and process are considered as "enabling factors" and outcome has been renamed as "results". Two dimensions (Network Conditions and Internal Performance Levers) within the Sustainability Performance Framework in Value Networks (Fig. 1) can be seen as "enabling factors", while the other dimension (TBL assessment) is related to the "results". On the whole, this requirement would mean that the user of the platform may (i) assess the "results" (lagging attribute) according to the status of the "enabling factors" (leading attributes) and (ii) use the "results" as feedback to activate rethinking / reengineering of the "enabling factors" according to a continuous improvement approach. Following up the chain of causes and effects will enable the organization to adjust its internal performance levers and possibly its network in order to achieve its desired performance objectives.

The second requirement relates to the support to interactive performance regulation between Network conditions and Internal Performance Levers, the two issues being, in fact, mutually dependent. This means that the user of the platform may be able to review and redefine the Internal Performance Levers based on the knowledge acquired on Network conditions and vice versa (i.e. to review and redefine the Network conditions if a company decides to make a principal change to the Internal Performance Levers).
The third and last requirement envisages the integration of relevant measures already present in existing standards and guidelines. Accordingly, the user of such a platform may (i) reuse all the existing knowledge without reinventing the wheel with new measures and (ii) make a benchmark through a set of indicators that are commonly adopted in industry. Literature review (see section 2) has provided the theory to this end through different standards and guidelines.

Design choices for the integrated assessment platform

The dimensions inside the Sustainability Performance Framework include areas of different nature. Network conditions and Internal Performance Levers are of intangible character: thus, even if their performance characteristics are visible in the state of practice of given business process areas, they have a more qualitative nature and this characteristics are not directly measureable with quantitative metrics. In this case, performance assessment is more difficult. To this concern, different rating scales were discussed above for measuring/assessing the state of practices and maturity models have been selected as the rating method. Opposite to this, TBL assessment concerns tangible performance characteristics that could be more easily measured through metrics/indicators. Thus, the main challenge of developing an integrated platform is dealing with this heterogeneity among the areas. More precisely, the differences in nature among the areas make it difficult to establish a unique assessment procedure. Therefore, the structure proposed for the performance measurement platform contains different assessment procedures. In our vision, two types of procedures were decided as main design choices.

– The first procedure adopts metrics: this is the case when the assessment object can be measured tangibly. In this case, Key Performance Indicators (KPIs) are defined or also identified from existing sources (i.e. standards and guidelines).
– The second procedure evaluates the quality of processes based on the existence of good / best practices. To this end, it is proposed to adopt the concept of “maturity assessment”, using maturity models as rating models. The potential to guide performance improvement has been pointed out in the previous section as one characteristic of maturity models, thus this choice is based on the scope of providing guidance for improvement once the weak practices have been identified. In particular, the CMMI methodology is proposed to be followed for the maturity assessment.

4. Integrated assessment platform: The proposition

The structure of the *Integrated Assessment Platform for Sustainability Performance* is shown in Fig. 2. This platform consists on a dashboard of intangible and tangible measures connected to the three dimensions of the Sustainability Performance Framework developed by [9]. As mentioned above, maturity assessment seems more appropriate for capturing intangible elements such as Network Conditions and Internal Performance Levers, while the TBL assessment would be developed using a procedure and based on metrics/KPIs.

The maturity assessment will result on a maturity profile, which can facilitate improvements by using a graphical language simple to business interpretation (a spider chart would be useful to this end). In particular, the maturity assessment is based on a questionnarie which, as suggested by García-Mireles et al. [26], enables the application of MMs by assisting in the evaluation of current status or improvement recommendations for an organization or a process. Maturity scores are assigned to each answer within the questionnaire in order to provide the values to draw the maturity profile. Moreover, the verbal descriptions of the various maturity states shall be considered a set of recommendations, and may need adjustment depending on the parameters determining the organizational context, such as industry and national regulatory framework.

The TBL assessment is made of a series of indicators divided into categories: the broader categories are related to sustainability themes (economic, environmental, social) and then subdivided into subcategories, following suggestions that came up from the standards and the reviewed guidelines. The measures within the subcategories could follow a logic of thresholds, so as ”traffic lights”, indicating the state of the subcategory to which they belong with respect to the achievement of a certain threshold aligned with the performance objectives.

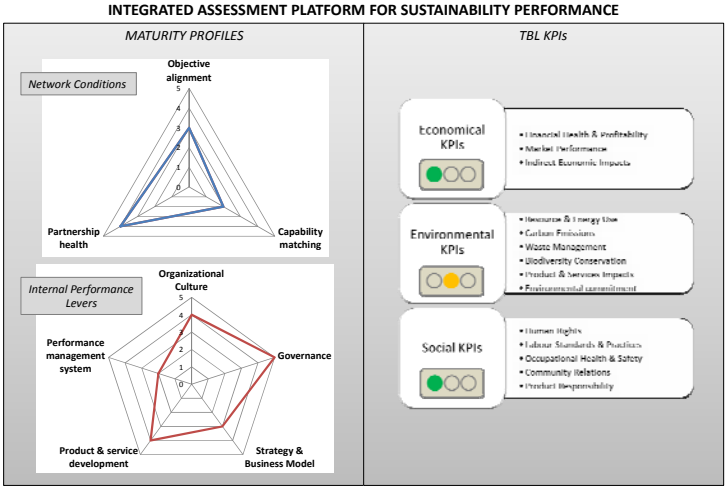

Fig.2. Graphical representation of the Integrated Assessment Platform.

In accordance with the design choices (section 4), two approaches (one for each procedure) are potentially envisioned in the platform: the two approaches should work together, being connected in order to enable analysis of impacts of leading on lagging attributes, accordingly with the envisaged cause-effect relationships.

5. First evidence from industry

The integrated assessment platform was taken through a preliminary validation process to early understand both the timely relevance and the application potential in selected contexts. To this end, two companies with different characteristics have been chosen. One company represents a mature incumbent from agricultural machinery manufacturing with revenue exceeding three billion Euro whereas the second company is a young entrepreneurial start-up that produces and leases out light city cars but considers itself a provider of mobility rather than an automobile manufacturer.

At an early stage during the development of the integrated assessment platform, a workshop with the producer of agricultural machinery, involving the company's key person for sustainable development, was conducted in order to find evidence for (or against) the validity of the propositions put forward in this work. This was achieved by testing the conceptual framework and the logic of cause and effect relationships proposed for sustainability performance (Fig. 1). A broad set of questions was created for this test, and its results were compared to the results of a GRI assessment conducted by the industrial partner himself. The questions used for the assessment represented an early version of what would later become the maturity model. The comparison showed some differences between the conclusions that could be derived from GRI assessment and those derived from our questionnaire. GRI suggested a positive picture of the company's sustainability performance, while our approach proofed useful in guiding the discussion towards performance weaknesses: in this way, it enabled an extension of the picture obtained by GRI assessment. On the whole, the workshop demonstrated the usefulness of our approach and provided some evidence for the logical propositions inherent to our work.

At an intermediate stage of development of the integrated assessment platform, a second workshop involving two leading engineers from the start-up company (among them one of the founders of the company) was conducted in order to test an updated draft of the questionnaire for the maturity assessment and a draft set of indicators for the TBL assessment. The obtained feedback was very useful to improve some of the questions and to realize whether some proposed indicators could be useful or not. Thus, both the maturity assessment and the TBL assessment were modified according to the feedback received. Furthermore, this second workshop indicated that the performance framework is of use even if one

area has to be excluded from the assessment. In this case, the company did not employ any formal performance management methods – nor did these seem necessary due to the small size and the strong leadership of the company. To this concern, then it may be asserted that the modularity of the questionnaire allowed to carry out even a partial maturity assessment, adapting to the company needs and contexts, without affecting the overall result achievable in understanding the company's maturity scale.

A main limitation that came up during both workshops was related to the people which should be involved in this type of assessment. It may require the participation of a variety of key personnel from relevant functional units and top management in order to have a clear overview of company's stakeholder network, its strategy, its overall operations and its variety of product and service offerings. This could constrain the results to be achieved if some key experts are missing in the workshop.

6. Concluding remarks

The measurement of sustainability performance in complex production value networks is becoming an important concern in today's networked industrial sector. The integrated assessment platform proposed here encompasses dimensions both at company level and network level, so not neglecting the effects that these levels may have in the overall performance of the network. This work is built on the sustainability performance framework whose dimensions (*network conditions, internal performance levers and TBL assessment*) have driven the development of a dashboard of measures which constitutes an integrated platform for sustainability assessment. The platform is compound by a maturity profile of network conditions and internal performance levers and a set of TBL KPIs which evaluate several sustainability-oriented outcomes. The envisaged connection among these elements follows a logic of cause-effect relationship, which was tested in a workshop with an industrial partner. The understanding of causes and effects will enable the company to adjust its internal performance levers and, possibly, its network conditions in order to achieve its desired performance objectives.

The main challenge for the development of the integrated assessment platform was dealing with the heterogeneity among its dimensions. This created the need of developing two different assessment approaches: one based on metrics, a *TBL assessment based on sustainability KPIs,* and the other one based on maturity measures, a *maturity assessment for network conditions and internal performance levers*. Maturity models have been identified as the more appropriate means for measuring qualitative values within our context. Both assessment procedures were tested in a workshop with an industrial partner, which provided elements for improvement and to identify practical challenges regarding the use of the platform.

The integrated assessment platform aims at becoming a tool relatively easy to use and helps to understand an organization's sustainability performance and to identify root causes for particular performance outcomes. It can also be considered as a tool for continuous improvement as the knowledge gained through its use can be considered to support the adjustment of performance drivers (if necessary) by acting on the adequate area at company or network level.

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References

[1] Beer,J.E.: Ansätze zur Messung von Nachhaltigkeit in komplexen Produktionsnetzwerken. Otto-von-Guericke-Universität Magdeburg (2012)

[2] Beer, J. E., & Liyanage, J. P.: Sustainability Performance in Modern Industrial Context: From Firm-centric to Network-based Assessment. In W. B. Lee, B. Choi, L. Ma, & J. Mathew (Eds.), Towards Integration and Interoperability in Engineering Asset Management. Proceedings of the 7th World Congress on Engineering Asset Management. Springer (2012)

[3] Joung, C. B., Carrell, J., Sarkar, P., & Feng, S. C.: Categorization of indicators for sustainable manufacturing. Ecological Indicators, 24, pp.148-157 (2013)

[4] Wongrassamee, S., Gardiner, P.D., Simmons, J.E.L.: Performance measurement tools: the Balance Scorecard and the EFQM Excellence Model. Measuring Business Excellence. Vol 7, No. 1, pp. 14-29 (2003)

[5] ISO 14031:1999 Environmental Performance Evaluation.

[6] Kaplan, R. S., Norton, D. P.: The balanced scorecard. Measures that drive performance. Harvard Business Review. January-February, pp. 71-79 (1992)

[7] Donabedian, A.: The Quality of Care: How Can It Be Assessed? The Journal of the American Medical Association (JAMA: The Journal of the American Medical Association), Vol. 260, No.12,pp. 1743–1748 (1988).

[8] Donabedian, A.: Evaluating the Quality of Medical Care. The Milbank Quarterly, Vol. 83, No.4, pp. 691–729 (2005).

[9] Beer, J., Liyanage, J.P.: Principal Components of a Governing Framework for Sustainability in Manufacturing Networks. In: Lee WB, Choi B, Ma L, Mathew J (eds) Towards Integration and Interoperability in Engineering Asset Management. Proceedings of the 7th World Congress on Engineering Asset Management. Springer (2012)

[10] Rowley,T.J.: Moving Beyond Dyadic Ties: A Network Theory of Stakeholder Influences. Academy of Management Review, 22(4), pp. 887–910 (1997)

[11]Provan, K. G., and Kenis, P.: Modes of Network Governance: Structure, Management, and Effectiveness. Journal of Public Administration Research and Theory, 18(2), pp. 229–252. (2007).
[12]Harland, C. M., Lamming, R. C., Zheng, J., and Johnsen, T. E.: A Taxonomy of Supply Networks, The Journal of Supply Chain Management, 37(4), pp. 21–27 (2001).
[13]ISO 14001:2004 Environmental Management System
[14]ISO 50001:2011 Energy management Systems – Requirements with guidance for use
[15]ISO 26000:2010 Guidance on Social Responsibility.
[16]SA 8000:2008 Social accountability.
[17]EMAS III Regulation, 2009. Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS).
[18]Global Reporting Initiative, G3.1 guidelines (2000 ‑ 2011) version 3.1 available at: [https://www.globalreporting.org/resourcelibrary/G3.1-Guidelines-Incl-Technical-Protocol.pdf]
[19]Moultrie, J., Clarkson, P.J., Probert, D.: Development of a Design Audit Tool for SMEs, The Journal of Product Innovation Management, Vol. 24 No. 4, pp. 335–368 (2007)
[20]Guttman, L.: A Basis for Scaling Qualitative Data. American Sociological Review, Vol. 9 No. 2, pp. 139–150 (1944)
[21]Becker, J., Knackstedt, R., Pöppelbuß, J.: Developing Maturity Models for IT Management - A Procedure Model and its Application. Business & Information Systems Engineering, 3 (2009)
[22]Röglinger, M., Pöppelbuß, J., Becker, J.: Maturity models in business process management. Business Process Management Journal, Vol. 18 Iss: 2 pp. 328 – 346 (2012)
[23]Paulk, M.C. Weber, C.V. Garcia, S.M. Chrissis, M.B.C. Bush, M.: Key Practices of the Capability Maturity Model Version 1.1. Software Engineering Institute. Paper 171 (1993)
[24]Macchi, M., Fumagalli, L.: A maintenance maturity assessment method for the manufacturing industry, Journal of Quality in Maintenance Engineering, Vol. 19 Iss: 3, pp.295 – 315 (2013)
[25]Herndon, M.A., Moore, R., Phillips, M., Walker, J., West, L.; Interpreting Capability Maturity Model® Integration (CMMI®) for Service Organizations – a Systems Engineering and Integration Services Example. Technical Note, CMU/SEI-2003-TN-005 (2003)
[26]García-Mireles, G.A., Moraga, M.A. and García, F.: Development of Maturity Models: A Systematic Literature Review. Proceedings of the EASE 2012 - Published by the IET, pp. 279-283 (2012)