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# Maturity models: identifying the state-of-the-art and the scientific gaps from a bibliometric study

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**Abstract** Maturity model has been increasingly approached by several researchers from various research areas in order to develop models that could assess the strengths and weaknesses of a system and/or a process, and to develop scripts for improvement. Additionally, they pursue the development of a process with desirable goals, such as a set of resources or practices, resulting in a more mature organization or system. This study provides an overview of the maturity models' literature and their main features while employing bibliometric analyses of publications from 2004 through 2014 aiming to identify scientific gaps that would serve as guides for future research. The analyses' results reveal that maturity models are highly applied in project management seeking for processes and/or systems improvement, and they can also be described as adaptable models which could be used in various research areas, as can be seen in the scientific gaps section. Therefore, the main contribution of this paper is to make the evolution of this subject and its importance better known, thus encouraging the use of maturity model in future researches, seeking the improvement of the current model.

**Keywords** Maturity model · Bibliometric analysis · Scientific gaps · Organizational evaluation

## Introduction

Organizations grow in a complex manner involving several evolutionary aspects, such as organizational, technical, strategic, among others. They realize more and more the need to assess their present situation, determine desirable future scenarios and verify possible and profitable ways that will lead them towards this evolution (Marx et al. 2012).

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As the technology progress and the introduction of management systems provide significant competitive benefits to organizations, they also need resources that support them to achieve desired goals. Maturity model is a method that has been increasingly growing and gaining notoriety, which determines the maturity levels based on the performances of the companies' process areas (Ngai et al. 2013).

The application and development of maturity models have increased in demand, since they can be used for strengths' and weaknesses' analyses, developing improvement plans and the company's evaluation when compared to other organizations' standards and best practices (Pigosso et al. 2013).

In general, the term 'maturity' can be defined as 'the state of being perfect, complete and ready', or more specifically as 'a measure used to evaluate the resources of an organization'. Hence, maturity implies an evolutionary process from an early stage towards a desired scenario or, in other words, a final stage (Marx et al. 2012). Furthermore, Harmon (2004) states that mature organizations do their business in a systematic way, while the others only get their results through the heroic efforts of determined individuals, who spontaneously create the approaches they intend to use.

Maturity models consist of several maturity levels reflecting the evolutionary path for a given area or process, being widely used for continuous improvement and benchmarking. With the help of the maturity models, organizations can assess their present situation and determine a future desired scenario, considering a number of predefined items (Marx et al. 2012).

Fischer (2004) determined five organizational change triggers, namely: strategy, controls, people, technology and process. They provide the components on which the resources will be evaluated, as the organization then proceed to the second dimension of the maturity model, during which the components formerly set will be evaluated at each one of the maturity stages. As for the model developed by Fischer (2004), they are: siloed, tactically integrated, process-driven, optimized enterprise, and intelligent operating network.

The maturity model designed by Fischer (2004) is appropriate to all organizations seeking to reach the maturity level in their businesses, since, through the evaluation of those change triggers, the gaps between their current situation and the future desired scenario are identified. By assessing those gaps at each level of the proposed model, the organization may create action plans that would ultimately help eliminate those lacunas, enabling the achievement of corporative goals.

Therefore, a maturity model contains essential elements and effective processes for one or more areas and/or systems, describing an evolutionary path of improvement, and turning premature processes into mature ones with improved quality and effectiveness (Garzás et al. 2013). A maturity model can be seen as a guide to best practices and also as a process assessment framework that could be employed step by step in an organization's low-cost evaluation process and planning improvement (Gorschek 2012).

Due to the benefits that the use of maturity model provides those organizations wishing to achieve a future desirable situation, the model has been used in various areas of study, covering areas of biological, human and exact sciences. Moreover, the implementation of maturity models in the organizations allows a better decision-making process, enlightening the managers as to their current processes' and services' status.

According to Liker and Morgan (2011) and León et al. (2011), maturity models have been developed in order to assess the organizations' competence, capacity level and sophistication based on a relatively extensive set of criteria. Consequently, a maturity

model could be analyzed as a structured dataset, which describes specific maturity aspects of an organization.

Spanyi (2004) believes that, even though maturity models are well-intentioned, they are mechanistic and do not capture the required attention from senior managers. The author also states that many of those models fail in recognizing that the organization's main purpose to develop new management practices is to improve the corporate performance.

Thereafter, the majority of these models do not take explicitly into account two fundamental organizational realities: companies are complex, both considering their business and their social systems, and, for them to achieve an exemplar business management performance, their leaders must work as a team, in a collaborative way.

This article briefly presents maturity models and their main feature, and also a bibliometric analysis, which verifies the contribution of articles that have been published from 2004 to 2014 on maturity models, while identifying scientific gaps for research advancement. Robinson et al. (2011) define scientific gaps as topics or areas where there is a lack of information or a limited capacity to achieve an understanding. In the present paper, there will be exposed the suggestions for future researches signalized both in the studied articles and by the analyzed authors.

The paper also exhibits analyses of the most cited articles and authors on maturity model, and, from these analyses, the scientific gaps will be identified in order to guide researchers on future studies. Additionally, it would allow them to recognize the most prominent authors so as to adopt them as references.

There are similar works in the extant literature, such as Souza and Gomes (2015), however, it focused on the scientific production on project management concerning the organizations' most expressive maturity models. They investigated articles published from 2010 to 2014 from the Web of Science, the Scopus and the Scielo databases, and the data analyses, such as the most influencing countries, the number of articles per country and the grouping of the articles according to the maturity model, were executed through the Zotero® software.

The bibliometric analysis provides an accurate and presumably objective method to measure the contribution of an article for the advancement of knowledge, and is a frequently used tool to analyze trends and performance on a particular subject (Yang et al. 2013). Thereupon, this bibliometric analysis is employed to better comprehend the evolution in the studies on maturity models within the academic community, and to verify their real efficiency in the business world.

This section exhibited an introduction to the paper, while the next one will be presenting a brief theoretical framework on maturity model. Then, the research method is described including the criteria adopted, the used databases and the tools employed in the analysis. Next, the obtained results are described and analyzed, while the last section presents the findings and proposals for future researches.

## Theoretical framework

In an immature organization, processes are generally improvised by people who are in direct contact with them, and, even though they had been specified, that does not mean the guidelines will be strictly followed. In this type of organization managers are focused on solving problems immediately, being informally known as firefighters, while deadlines and budgets are routinely exceeded, since the planning is not based on actual estimates. An

immature organization does not have an objective way to verify the quality of products or solving problems, turning quality into something difficult to achieve (Paulk et al. 1993).

On the other hand, a mature organization possesses a broad process control enabling their development management and maintenance. Managers communicate accurately with staff and new workers about processes, and the activities are carried out according to the plan. Processes are updated whenever necessary through pilot testing and cost-benefit analysis seeking for improvements, besides, rules and responsibilities are clear to the entire organization, especially those involved in the project. In a mature organization, managers monitor the quality of products and processes, therefore, since deadlines and budgets are based on historical data, the results of costs, functionality and quality can be usually achieved (Paulk et al. 1993).

According to Schmietendorf et al. (2000), Poppendieck (2004) and Paulk et al. (1993), maturity in an organization can be seen as an extension in which the worked process is explicitly defined, very well managed, fully controlled and effective. Hence, their respective models come to help organizations achieve the desired benefits.

Maturity model happens in development stages and involves the knowledge of the capacity of the areas of process, wealth and consistency of the whole system (Randeree et al. 2012). The maturity model is conceptualized through a set of elements that describes the development of a particular area of interest and assists in describing a process that a system may eventually develop in order to achieve a desirable goal, by means of a set of resources or practices, resulting in a more mature organization (Pigosso et al. 2013).

Maturity models can be used for three main purposes: analysis of strengths and weaknesses, development of a roadmap for future improvements and evaluation of the company when compared to other organizations' standards and best practices (Pigosso et al. 2013). There are different classifications of maturity models concerning their structures: (a) capability maturity models and (b) maturity matrix. However, there are also variations of models adapted to the aforementioned ones.

After several unfulfilled promises regarding productivity and quality improvements, all of which would be derived from the deployment of new technologies and software methodologies in organizations, developers have identified that the real problem is the lack of ability to manage software processes. Within various organizations, the budgeting and planning of projects take place too late in the timeline, thus, the benefits that could be achieved from new software methods or technologies are not possible due to the lack of discipline in the planning stage (Paulk et al. 1993).

Paulk et al. (1993) had also stated that the Software Engineering Institute (SEI) started the development of a process-maturity framework in November 1986 that would help software developers improve their processes. In September 1987, SEI gave a brief description of the process-maturity framework and, after a few more years of experience with this method, it was implicated in the Capability Maturity Model (CMM).

The capability maturity model (CMM), which is illustrated in Fig. 1 (Jin et al. 2014), consists of a five-stage structure of evolution, or capacity levels, or process maturity, describing an evolutionary improvement path from an immature process to a mature one, disciplining the process (Albu and Panzat 2010).

CMM is characterized by its comprehensive and complex architecture, because, unlike maturity matrices, each maturity level on a CMM has its own process areas. It is a specific maturity level that can only be achieved if the practices and objectives of all process areas in a previous level are met (Jin et al. 2014).

An extension of the CMM with best practices, the Capability Maturity Model Integrated (CMMI), is used in the areas of product and service development, service providers,

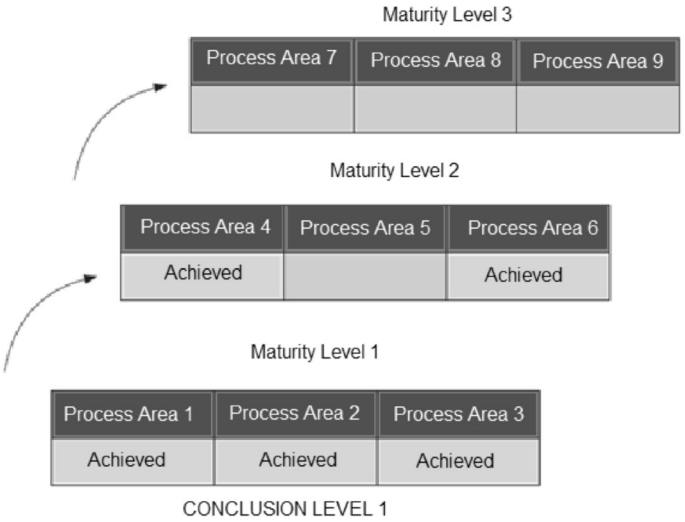



**Fig. 1** Capability maturity model (*Source* Jin et al. 2014)

management, product delivery, and acquisition of services and products. It provides the organization with a guide for continuous improvement through the integration of inter-organizational functions, focusing on objectives and priorities by orienting quality processes and establishing a benchmark to evaluate the ongoing process.

The CMMI is represented by stages and continuous representation, wherein the first one is similar to the CMM presenting five maturity stages, while the continuous representation uses six capability levels to improve the process. Each level corresponds to a generic goal and a series of practices, and each level is analyzed separately. Capacity levels focus on increasing the ability to control, the performance and the organizations' improvement in specific process areas (Ngai et al. 2013).

A rapid growth in the development and use of maturity matrixes has been noticed in management practices in industrial enterprises since 1990, approximately. These matrixes were developed by academic researchers, people involved in industrial processes, such as managers and consultants, who used the original Quality Management Maturity Grid (QMMG) by Crosby as a reference (Maier et al. 2012).

The Crosby's QMMG contains various maturity levels, usually from 3 to 6 levels (Stage I—uncertainty; Stage II—awakening; Stage III—enlightenment; Stage IV—wisdom; Stage V—certainty), forming an evolutionary pathway of resources, which is used as groundwork to the maturity matrix illustrated in Fig. 2. For any given factor in a specific maturity level, detailed descriptions are provided to serve as a basis for the measurement of maturity. For inspecting the maturity level of each key factor, companies become aware of their weaknesses and, consequently, may improve relevant activities (Crosby 1979; Jin et al. 2014).

The main purpose of a maturity matrix is to measure and encode capabilities or typical behaviors that reflect on best practices to effectively accomplish specific tasks and goals. A maturity matrix usually includes several key aspects that give an overview of the area of interest, in which the progress in each of the intermediate or transitional stages are described and interpreted. Maturity matrixes have been successfully applied to evaluate

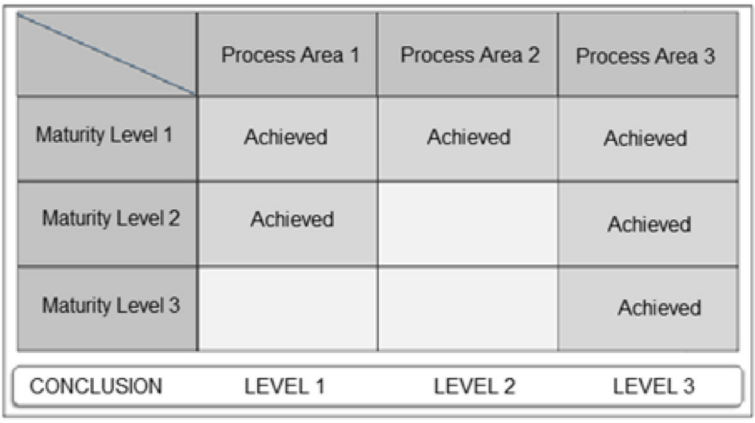



**Fig. 2** Maturity matrix (*Source* Jin et al. 2014)

strategic and operational capabilities in quality management, product development, communication, data security and risk management organizations (Golev et al. 2015).

To develop maturity matrixes, Maier et al. (2012), suggest a script consisting of four phases: planning, development, evaluation, and maintenance. For each phase, a number of points and decision options are discussed. Progression through some phases can be an iterative work and may have to be re-evaluated (Maier et al. 2012).

"The decision points and their respective decision's options for each one of the stages suggested by Maier et al. (2012) are: at the first stage (planning): 1—specify audience, e.g. users; 2—define objective, e.g. entities; 3—clarify scope, e.g. general or specific domain; and 4—define success criteria, e.g. high-level and specific requirements.

The second stage (development) can be defined as: 1—select areas of processes (components and theoretical framework); 2—select maturity levels; 3—formulate text cell, e.g. type of formulation (prescriptive or descriptive), source of information (synthesize the point of view of future users or comparison of other organizations' practices), and mechanism of formulation (inductively generated from descriptions of practices or deducted from the subjacent logic); and 4—set delivery mechanism, e.g. focus on the evaluation process or focus in the final results (Maier et al. 2012).

The decision points and their options at the third stage (evaluation) are: 1—validation, i.e. correspondence between the author's intent and the user understanding; and 2—verification, i.e. matching specific requirements. In terms of the fourth stage (maintenance), they are: 1—check reference, if applicable; 2—keep results database, if applicable; and 3—document and communicate development process and results, specific to the public (Maier et al. 2012)".

According to Maier et al. (2012), despite the existence of a script to be followed, there can be variation of the points within the phases, although the phases are consistent and, therefore, can be applied in various fields. Even though it is mainly targeted as a guide to future developments of maturity matrices, the script can be used for evaluative purposes of current observations. The script works as a warning to researchers and professionals to a set of decisions that must be made when developing a maturity matrix (Maier et al. 2012).

Maier et al. (2012) affirm that the differentiation of the maturity matrixes models and CMM is not a trivial task, because frameworks are improvements that complement each other. Nevertheless, some points may differ in orientation, in the evaluation mode and in

the model intention. With respect to orientation, while the CMM only applies to more specific sectors, maturity matrix may be enforced at any company or sector, considering it does not require a specific process for its execution.

Typically, the CMM is assessed by a Likert or binary scale based on questionnaires that evaluate the process performance. The maturity matrix, in turn, is structured in a matrix with maturity levels and key aspects of the process performance, creating a series of cells which contains text describing the performance characteristics required at each level. Maturity matrixes are less complex than the CMM, being used as a diagnostic or improvement tool, while the CMM follows a formatted and internationally recognized standard (Maier et al. 2012).

Schmietendorf et al. (2000) proposed the Performance Engineering Maturity Model (PEMM), which is similar to the CMM, in order to determine the maturity of the Performance Engineering (PE) process within the software development, and with the purpose of evaluating PE processes and their integration. There were determined five level: Stage I—uncoordinated practices; Stage II—consideration of PE sub process; Stage III—Entire PE Process Definition; Stage IV—successfully integrated and proved PE process; and Stage V—Optimized PE process.

The lean capability model, based on the continuous improvement (CI) maturity model, has been proposed by Jorgensen et al. (2007), which illustrates a gradual but steady development of CI through five maturity stages arising from the adoption of some behaviors that, when integrated, provide organizational capabilities. Stage one consists of behavioral activities, such as "firefighters", through the creation of systems, procedures and organization processes. The development of CI becomes more structured and focused on strategy, finally reaching stage five, where a solid learning about CI is obtained in the organization.

The lean capability model has been elaborated based on experiments that the researchers had with organizations and key people implementing lean in order to develop lean capabilities and long-term sustainability. The collected data were sorted into five maturity stages similar to the CI maturity model, namely: Stage I—Sporadic production optimization; Stage II—Basic lean understanding and implementation; Stage III—Strategic lean interventions; Stage IV—Proactive lean culture; and Stage V—Lean in the extended manufacturing enterprise (EME) (Jorgensen et al. 2007).

There are distinct types of maturity models that, similarly to the aforementioned ones, had been designed based on existent models, adapting them according to the organizations' needs and goals.

## Research methodology

To conduct the bibliometric analysis consistent with what was pre-established in this article, a search for articles has been carried out on the Scopus and Web of Science platforms, which are scientific multidisciplinary articles databases. They bring together a wide range of journals from relevant publishers that provide a global access point to most of the scientific literature published internationally, such as: Elsevier, Springer, Wiley-Blackwell, Taylor & Francis, Stage, Emerald and others.

Articles published in journals are the dominant means for the disclosure of results in the areas of natural sciences, engineering and biomedical research (Mongeon and Paul-Hus 2016), and so they had been chosen as the main database for this research. Bibliometric

analyses use bibliographic data stored in electronic databases and the studies are carried out under the premise that they encompass different databases, thus the need to properly choose which ones will be used (Uriona-Maldonado et al. 2012).

The traditional method of bibliometric analysis is to conduct a research on the trending topics of a particular field of study, mostly based on the publication date, the institute and journal, author, country and subject of research, besides the frequency of the keywords, among others. Bibliometric analysis is being increasingly applied to analyze the relationship among keywords, country, research institute and author (Zhuang et al. 2013).

For this bibliometric analysis, the subject to be examined was initially established, in this case "maturity model", and, therefore, the database platforms to be used and the search parameters are defined. This research will be using the Scopus and Web of Science platforms and the following parameters: article tittle containing the term "maturity model", data range from 2004 to 2014 and document type restricted to "article".

The aforementioned parameters were used as filters in both databases in order to increase the accuracy of the results, and, after their application, 156 (one hundred fifty-six) documents have been found in Scopus and 107 (one hundred-seven) documents in Web of Science.

Scopus platform is a large depository for revised summaries and literature citations (scientific journals, books and conference proceedings), which provides a comprehensive overview of research production in the world in science, technology, medicine, social sciences and arts and humanities, enabling several intelligent features and tools to track, analyze and visualize researches. It becomes even more global when it comes to researches, being an interdisciplinary and collaborative tool (Elsevier 2015).

The data extracted from the database platforms were assigned to various analyzes, such as: the most cited articles and keywords, the number of publications of the most cited authors, the H-index and the institution of the most cited authors, their citations' quantity and evolution (regarding a variety of subjects), their last published articles (topic: maturity model), the impact factor (SJR) of the journal in which their last article on maturity model has been published and their proposals for future research.

The evolution of the subject within the pre-established period was retrieved from the Scopus platform, while, in determining the most cited keywords, it was necessary to export all the keywords found in the studied articles in a format compatible with Excel, so they could be properly treated and have their frequencies analyzed.

The most cited articles could be also identified from the platform by selecting the option "cited by", as well as those articles' information, such as authors, journal, the journal's impact factor, publishing year, volume, issue, and how many times the article has been cited in other publications.

Regarding the most cited authors, the following analyzes have been made by using the authors' names as filters in the Scopus database: number of publications, h-index, number of citations in different themes, evolution of citations, and the last published article on maturity model. The impact factor of the journal in which the author's last article on maturity model was published could be also retrieved within this platform.

For the identification of the scientific gaps, the latest articles published on maturity model of the most cited authors were analyzed one at a time, when their future studies proposals or research continuation have been observed.

Regarding the data obtained from the Web of Science platform (WoS), the following analyses were conducted: the most cited articles, the most cited authors and their network. The WoS platform also allows the identification of the most cited articles, however, duplications with articles already identified in the Scopus platform were noticed. A further investigation showed that all items presented in the WoS had been already exhibited in the

Scopus database, thus, the later has been determined as the primary data source for this study. The Sci$^2$Tool computational tool was employed in the recognition of the most cited authors on maturity model. Since this tool is only compatible with the WoS data format though, that was the chosen database when creating the most cited authors' network on model maturity.

For the analysis of the most cited articles, a combination of data from both databases has been carried out by checking whether the most cited articles in both bases corresponded well, besides verifying the veracity of those articles being the ten (10) items with higher citations on the subject.

The research was bounded by documents classified as "articles", because it allows the scientific gaps on maturity model to be identified, as well as providing greater scientific reliability.

The domain on the characterization of maturity model publications and the identification of scientific gaps are made possible based on the data obtained by means of the Scopus and Web of Science databases. The various analyzes were allowed due to the transformation of the collected data on relevant information to perform a consistent analysis of the ten (10) most cited articles on maturity model, the ten (10) most used keywords, 10 (ten) most cited authors and last article on maturity model published by each of the ten (10) most cited authors.

Thereby, it should be emphasized that the first three aforementioned analyzes enable the knowledge on the development and characterization of publications on maturity model, while the last one enables the identification of scientific gaps.

The bibliometric analysis of the collected data was performed by two software tools: Microsoft Excel and Sci$^2$Tool. Using Microsoft Excel spreadsheets, graphs and charts based on information taken from both databases were obtained, in addition to enabling the identification of the most cited keywords from the Scopus platform, while the Sci$^2$Tool tool allowed the identification of most cited authors as well as their network formation through the data extraction in the Web of Science platform.

The last article on maturity model of each of the ten (10) most cited authors was given a special attention in order to verify the authors' proposals for future research, forming the set of scientific gaps. Figure 3 shows the flow of steps performed for the bibliometric analysis.

The search has been restricted to the first ten most cited articles and the first ten most cited authors, because, in doing so, the study's relevance was guaranteed and it was possible to perform a more thorough analysis of the articles and the most cited authors on the subject. Had a greater amount of articles and authors been analyzed, it would have required a longer search and, perhaps, the main objectives would not be reached, which is to identify the most important articles and authors who effectively collaborate to the subject "maturity model" and to acknowledge scientific gaps. Therefore, the authors decided to scrutinize only 10 articles and 10 authors, which would end up providing a list of the top articles and authors on maturity model that is considered satisfactory for this research.

## Results and discussion

### Analysis of the evolution of publications on maturity model, research areas and most frequently used keywords

A sharp increase is observed in the number of published articles on maturity model, considering that the study of articles published from 2004 until 2014 enables us to identify the evolution of research on the subject, as shown in Fig. 4.

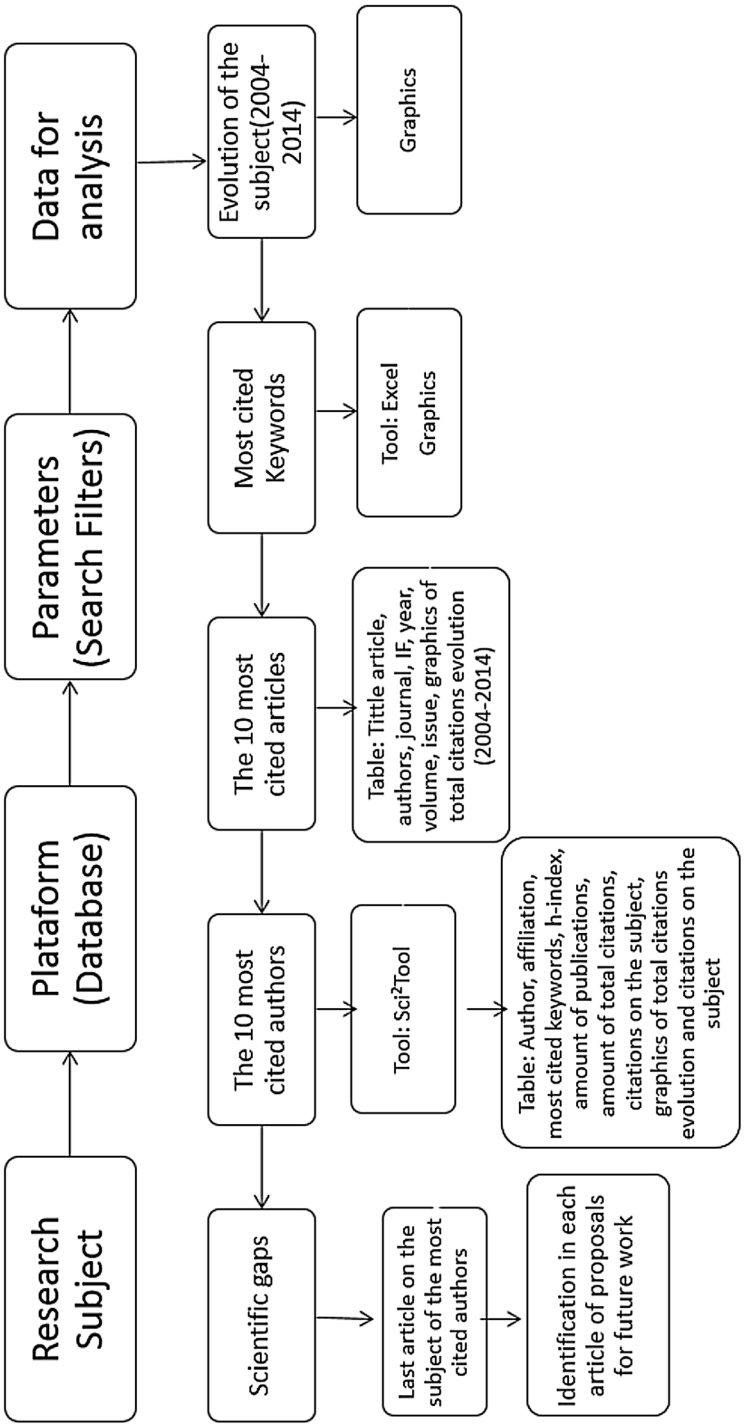



**Fig. 3** Steps flow to perform the bibliometric analysis

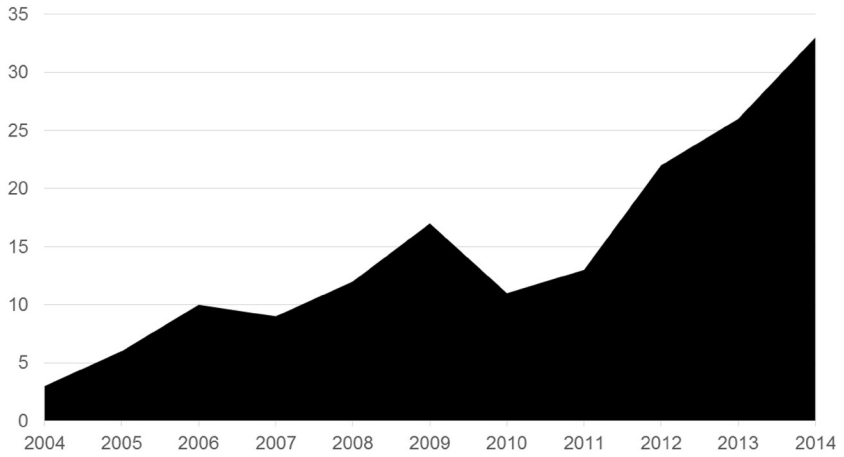



**Fig. 4** Evolution of the publications on maturity model over the period of 2004–2014 according to the Scopus database

An increase in the number of published articles on maturity model is shown in Fig. 4, depicting that, from the end of 2007 to early 2009, there was a significant evolution, which reappears at the end of 2011 and remains in progress until early 2014.

Figure 5 exhibits the areas that have been publishing articles on maturity model, and the subject importance to the development of scientific knowledge can be identified through the correlation among research areas and the amount of articles that have been published on the subject in each of them.

Despite maturity model being employed in various areas of research, Fig. 5 highlights its concentration in the exact sciences, especially in: computer science, engineering and business, management and accounting.

In order to identify what are the topics that have been studied along with maturity model, it was performed an analysis of the most used keywords in articles on the subject. The keyword "maturity model" was removed from the analysis, since the goal is to identify the keywords that have been addressed along with it.

The keywords "project management" and "performance" are the most used in articles on maturity model, comprising approximately 1.30% of total keywords (see Online Resource 1). Accounting for all the keywords identified in the articles on maturity model, except the very keyword "maturity model", the total value of 460 was obtained (four hundred and sixty), but many of them were employed only once.

The keyword "CMMI" or "Capability Maturity Model Integration" is approximately 1.09% of the total of the keywords used in the articles on maturity model, since CMMI is an adaptation of the CMM model.

The most used keywords are "Project management" and "Performance", which reinforces the idea that maturity model is largely employed along with project management in order to guarantee continuous improvement, thus seeking to achieve a desired performance.

## Bibliometric analysis of the ten most cited articles on maturity model

Continuing with the analysis of the characterization of publications on the topic, the ten (10) most cited articles on maturity model are tabulated as shown in Table 1, including

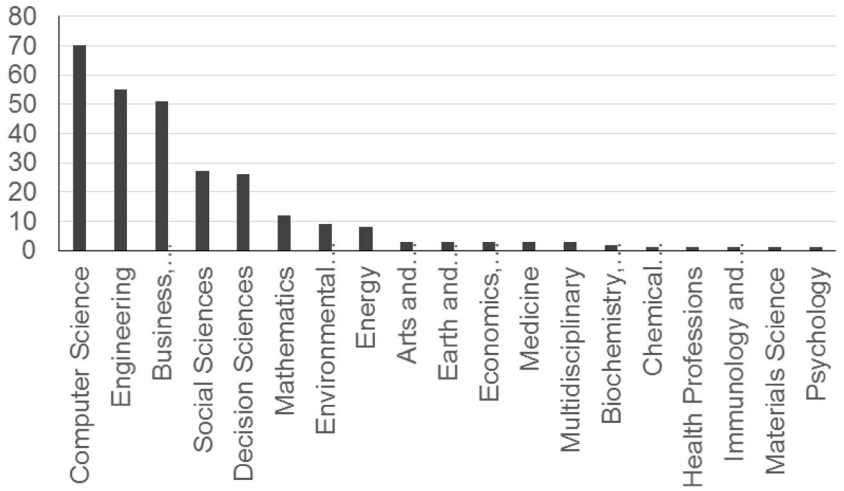



**Fig. 5** Research areas where articles were published on maturity model according to the Scopus database

the article's title, the authors, the journal to which it belongs, volume and edition, the journal's impact factor obtained from SCImago Journal Rank (SJR) in 2014, the year of publication of the article, the amount and evolution of the quotations from the year 2004 until 2014.

The most cited article, "E-government maturity models: Extension of the Layne and Lee model" by Andersen K.V. and Henriksen H.Z., proposes a reorientation of the government's electronic program using maturity models focusing on applications for the improvement of activities.

From Table 1 it is possible to extract Fig. 6 displaying citations' evolution through the years, identifying that between the years of 2007 and 2008 there was an intensification of mentions of maturity model.

Table 2 is obtained from Table 1 by analyzing the articles' respective years of publication and citations evolution in the established period (2004–2014). It can be noticed that, even though one of the top 10 most cited articles had been published in 2004, its largest citation period occurred in 2010, as well as it is clear that the articles started to be more heavily quoted from 2009 on. This means that, although they have been published since 2004, the articles which make up the 10 most cited articles still impart strong scientific collaborations to current researchers.

Among the ten (10) most cited articles, 3 (three) of them were published in the Journal Government Information Quarterly, and other three (3) articles were published in journals of the management area, namely: Information Systems Management, Industrial Management and Data Systems, Supply Chain Management-An International Journal, as can be seen in "Online Resource 2".

The analysis in Table 1, with respect to the titles of the most cited articles and the journals they are published in, confirms what has been seen in "Online Resource 2" regarding the various research areas in which the subject is approached. Maturity model can be adapted to many different situations and areas of study, since it will help achieve a better performance.

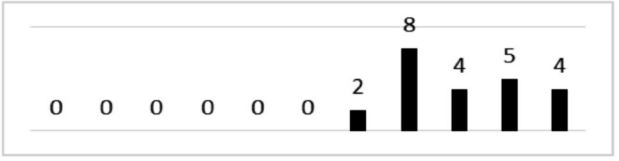
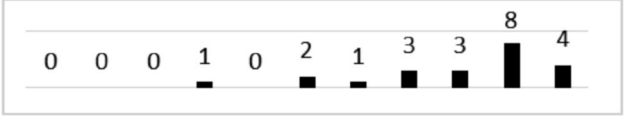
**Table 1** Bibliometric analyses of the 10 most cited articles on maturity model in the period from 2004 to 2014

| Title | Authors | Journal | FI/ SJR (2014) | Year | Volume | Edition | Total of citations | 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 |
|---|---|---|---|---|---|---|---|---|
| E-government maturity models: extension of the Layne and Lee model | Andersen K.V., Henriksen H.Z. | Government Information Quarterly | 1.203 | 2006 | 23 | 2 | 192 | 0 0 0 3 18 20 18 49 36 20 28 |
| The development of a supply chain management process maturity model using the concepts of business process orientation | Lockamy, A; McCormack, K | Supply Chain Management-an International Journal | 1.931 | 2004 | 9 | 3–4 | 108 | 0 1 3 7 8 15 17 10 14 16 17 |
| A maturity model for the implementation of software process improvement: an empirical study | Niazi M., Wilson D., Zowghi D. | Journal of Systems and Software | 1.381 | 2005 | 74 | 2 | 98 | 0 3 8 7 14 11 18 7 12 11 7 |
| Software Maintenance Maturity Model (SMmm): the software maintenance process model | April A., Hayes J.H., Abran A., Dumke R. | Journal of Software Maintenance and Evolution | 0.794 | 2005 | 17 | 3 | 53 | 0 0 5 3 5 8 4 11 8 4 5 |

**Table 1** continued

| Title | Authors | Journal | FI/ SJR (2014) | Year | Volume | Edition | Total of citations | 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 |
|---|---|---|---|---|---|---|---|---|
| Maturity model for IT outsourcing relationships | Gottschalk P., Solli-Saether H. | Industrial Management and Data Systems | 0.846 | 2006 | 106 | 2 | 52 | 0 0 1 4 5 18 7 4 5 6 2 |
| Service-oriented architecture: myths, realities, and a maturity model | Hirschheim, Rudy; Welke, Richard; Schwarz, Andrew | MIS Quarterly Executive | 1.172 | 2010 | 9 | 1 | 33 | 0 0 0 0 0 0 3 10 8 5 7 |
| An Open Government Maturity Model for social media-based public engagement | Lee G., Kwak Y.H. | Government Information Quarterly | 1.203 | 2012 | 29 | 4 | 33 | 0 0 0 0 0 0 0 0 0 15 18 |
| Conception, development and implementation of an e-government maturity model in public agencies | Valdes, Gonzalo; Solar, Mauricio; Astudillo, Hernan; Iribarren, Marcelo; Concha, Gaston; Visconti, Marcello | Government Information Quarterly | 1.203 | 2011 | 28 | 2 | 24 | 0 0 0 0 0 0 0 3 7 8 6 |

**Table 1** continued

| Title | Authors | Journal | FI/ SJR (2014) | Year | Volume | Edition | Total of citations | 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 |
|---|---|---|---|---|---|---|---|---|
| A PACS maturity model: a systematic meta-analytic review on maturation and evolvability of PACS in the hospital enterprise | van de Wetering, Rogier; Batenburg, Ronald | International Journal of Medical Informatics | 0.803 | 2009 | 78 | 2 | 23 |   |
| The project management maturity model | Kent Crawford J. | Information Systems Management | 0.441 | 2006 | 23 | 4 | 22 |   |

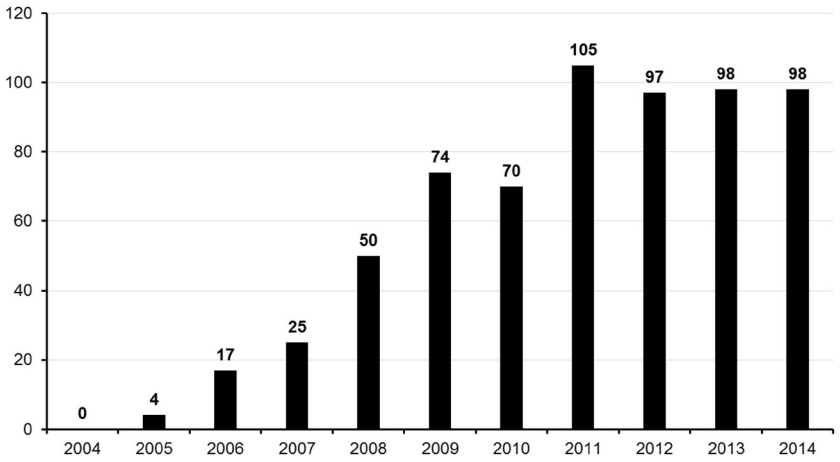



**Fig. 6** Evolution of citations from 2004 to 2014 according to the Scopus database

## Bibliometric analysis of the ten most cited authors on maturity model

After this previous analysis, information about the first authors who were most cited among articles on maturity model from 2004 to 2014 were compiled in Table 3. Table 3 contains the names of the most cited authors in descending order with respect to citations in articles on maturity model and the institution to which they belong. Further information can be extracted from these authors' publications in various areas and research topics, such as: the most used keywords by each one of them, h-index, number of publications and the number of citations during the period of 2004–2014.

Regarding the evolution of citations over the years, it is being shown the evolution of how many times the author was quoted in various subjects. Below it is the evolution of how many times the author's articles on maturity model have been cited and, therefore, it is possible to check the impact of the aforementioned articles on the scientific community and the general impact of this author. Figure 7 illustrates the network of authors and their most cited co-authors in articles on maturity model. As a result of the network analysis, the authors are placed in descending order, since the circle diameter and the color tone allow this allocation. The larger the circle diameter and the more intense its hue, the greater the number of author's citations.

Table 3 shows how many times the authors have been cited for their work in general and, immediately below, how many times they are cited for their work on "maturity model". Therefore, Lackamy and McCormack together have produced articles on maturity model that were cited 109 (one hundred and nine) times by other authors, which, in other words, means that they have a huge impact on scientific research. However, when analyzing their citations in general they do not have such a high impact as their colleagues in the group of the ten most cited authors.

Table 4 shows the relationship between the institutions the 10 most cited authors belong to and the citations' evolution of their articles on maturity model.

Considering the institutions with more citations on maturity model identified in Table 4, which could also be checked out in "Online Resource 3", the ones presenting more than 100 cited articles are Samford University, at the Brock School of Business and DRK Research, both from Birmingham, USA. The institutions exhibiting a range from 90 to 99

**Table 2** Analysis of the citations evolution in the period from 2004 to 2014 with the articles' year of publication

| Title | Year of publication | Citations evolution (2004–2014) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| E-government maturity models: extension of the Layne and Lee model | 2006 | 0 | 0 | 0 | 3 | 18 | 20 | 18 | **49** | 36 | 20 | 28 |
| The development of a supply chain management process maturity model using the concepts of business process orientation | 2004 | 0 | 1 | 3 | 7 | 8 | 15 | **17** | 10 | 14 | 16 | **17** |
| A maturity model for the implementation of software process improvement: an empirical study | 2005 | 0 | 3 | 8 | 7 | 14 | 11 | **18** | 7 | 12 | 11 | 7 |
| Software Maintenance Maturity Model (SMmm): the software maintenance process model | 2005 | 0 | 0 | 5 | 3 | 5 | 8 | 4 | **11** | 8 | 4 | 5 |
| Maturity model for IT outsourcing relationships | 2006 | 0 | 0 | 1 | 4 | 5 | **18** | 7 | 4 | 5 | 6 | 2 |
| Service-oriented architecture: myths, realities, and a maturity model | 2010 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | **10** | 8 | 5 | 8 |
| An Open Government Maturity Model for social media-based public engagement | 2012 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | **18** |
| Conception, development and implementation of an e-government maturity model in public agencies | 2011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 7 | **8** | 6 |
| A PACS maturity model: a systematic meta-analytic review on maturation and evolvability of PACS in the hospital enterprise | 2009 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **8** | 4 | 5 | 4 |
| The project management maturity model | 2006 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 3 | 3 | **8** | 4 |

The numbers in bold represent the higher citation value for the article between 2004 and 2014

**Table 3** Most cited authors on maturity model

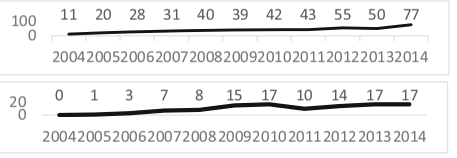
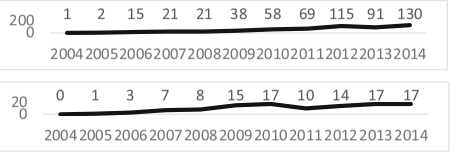
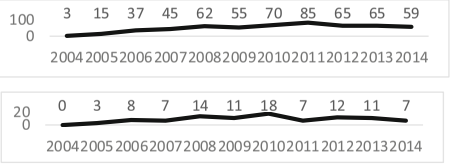
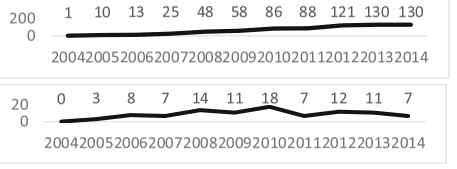
| Most cited authors | Affiliation | Most used keywords | h-index | Publication | Citations (C) | Maturity model citations (M.M.C) | | Evolution of citations |
|---|---|---|---|---|---|---|---|---|
| Lockamy,A | Samford Univ, Brock Sch Business, Birmingham, AL USA | Supply Chain Management | 10 | 28 | 536 | 109 | C<br>M.M.C |  |
| McCormack, K. | DRK Research, Birmingham, United States | Supply Chain Management | 10 | 21 | 561 | 109 | C<br>M.M.C |  |
| Wilson, D. | University of Technology Sydney, Faculty of Information Technology, Sydney, Australia | Software process improvement (SPI) | 9 | 33 | 561 | 98 | C<br>M.M.C |  |
| Niazi, Mahmood K. | King Fahd University of Petroleum and Minerals, Information and Computer Science Department, Dhahran, Saudi Arabia | Systematic literature review | 14 | 60 | 710 | 98 | C<br>M.M.C |  |

**Table 3** continued

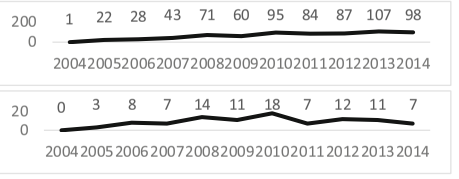
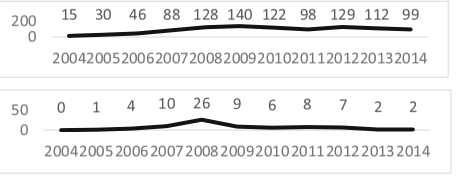
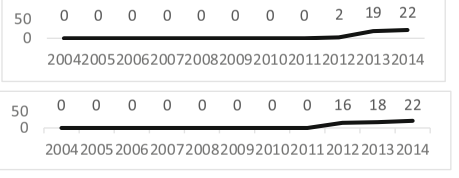
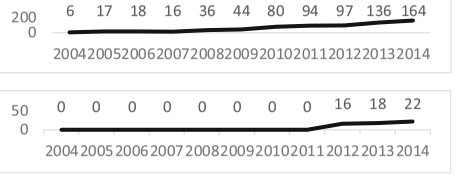
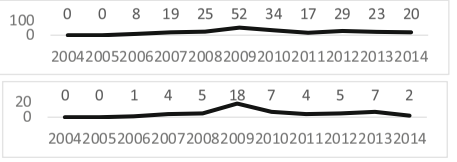
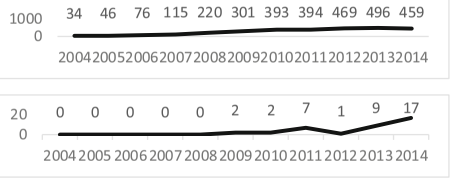
| Most cited authors | Affiliation | Most used keywords | h-index | Publication | Citations (C) | Maturity model citations (M.M.C) | | Evolution of citations |
|---|---|---|---|---|---|---|---|---|
| Zowghi, Didar | University of Technology Sydney, Research Center for Human Centered Technology Design, Sydney, Australia | Non-functional requirements (NFRs) | 12 | 83 | 696 | 98 | C<br>M.M.C |  |
| Gottschalk, Petter | Institute for Leadership and Organizational Management, Department of Leadership and Organizational Behaviour, Oslo, Norway | Knowledge management | 17 | 150 | 1007 | 75 | C<br>M.M.C |  |
| Lee, Gwanhoo | American University, Kogod School of Business, Washington, United States | Process ambidexterity | 2 | 9 | 43 | 56 | C<br>M.M.C |  |
| Kwak, Young Hoon | George Washington University, Department of Decision Sciences, Washington, United States | Project management | 13 | 36 | 708 | 56 | C<br>M.M.C |  |

**Table 3** continued

| Most cited authors | Affiliation | Most used keywords | h-index | Publication | Citations (C) | Maturity model citations (M.M.C) | | Evolution of citations |
|---|---|---|---|---|---|---|---|---|
| Solli-Sæther, Hans | BI Norwegian Business School, Oslo, Norway | Outsourcing | 7 | 24 | 227 | 53 | C<br>M.M.C |  |
| Piattini, Mario | Universidad de Castilla-La Mancha, Alarcos Research Group, Ciudad Real, Spain | Software process improvement (SPI) | 25 | 587 | 3003 | 39 | C<br>M.M.C |  |

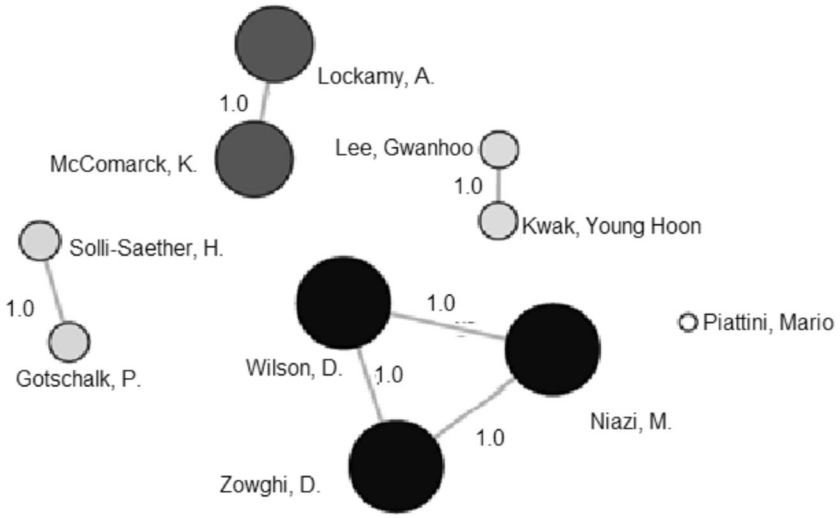



**Fig. 7** Network of the most cited authors on maturity model obtained through the Sci$^2$Tool

cited articles are: University of Technology Sydney, at the Faculty of Information Technology in Sydney, Australia; King Fahd University of Petroleum and Minerals, at the Information and Computer Science Department in Dhahran, Saudi Arabia; and University of Technology Sydney, at the Research Center for Human Centered Technology Design in Sydney, Australia.

Next, encompassing a scope from 70 to 80 cited articles, it is the Institute for Leadership and Organizational Management, at the Department of Leadership and Organizational Behaviour in Oslo, Norway. The American University, at the Kogod School of Business in Washington, USA, the George Washington University, at the Department of Decision Sciences, also in Washington, and the BI Norwegian Business School in Oslo, Norway, presents an amount of 40–60 cited articles. Lastly, the Universidad de Castilla-La Mancha, from the Alarcos Research Group in Ciudad Real, Spain, is ranked with less than 40 cited articles on maturity model.

From the data collected to build the evolution of the citations on "maturity model", it was observed that Piattini has three (3) articles on the subject, namely: "IQM3: Information quality management maturity model" which was cited 24 (twenty-four) times, "MIS-PyME software measurement capability maturity model - Supporting the definition of software measurement programs and capability determination" cited 8 (eight) times, and "A maturity model for the Spanish software industry based on ISO standards" cited 7 (seven) times, totaling 39 (thirty-nine) references on maturity model.

It can also be noticed, among the ten most cited authors, Piattini is the one with the least amount of citations on the subject, whereas when analyzing in a general context he stands out, since he has the largest number of citations when compared to the others.

Still from Table 3, the author with the highest impact on scientific research in a general context, accounted for 3109 (three thousand, one hundred and nine) citations, exerts very little impact when it comes to the subject of "maturity model", in this case 38 (thirty-eight) citations.

The bibliometrical h-index was seen in Table 3, which measures the production of a scientific researcher, wherein the index "h" stands for the number of articles having greater

**Table 4** The 10 most cited authors' affiliations and the citations evolution of their articles on maturity model

| Affiliation | Maturity model citations (M.M.C) | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Samford Univ, Brock Sch Business, Birmingham, AL USA | 109 | 0 | 1 | 3 | 7 | 8 | 15 | 17 | 10 | 14 | 17 | 17 |
| DRK Research, Birmingham, United States | 109 | 0 | 1 | 3 | 7 | 8 | 15 | 17 | 10 | 14 | 17 | 17 |
| University of Technology Sydney, Faculty of Information Technology, Sydney, Australia | 98 | 0 | 3 | 8 | 7 | 14 | 11 | 18 | 7 | 12 | 11 | 7 |
| King Fahd University of Petroleum and Minerals, Information and Computer Science Department, Dhahran, Saudi Arabia | 98 | 0 | 3 | 8 | 7 | 14 | 11 | 18 | 7 | 12 | 11 | 7 |
| University of Technology Sydney, Research Center for Human Centered Technology Design, Sydney, Australia | 98 | 0 | 3 | 8 | 7 | 14 | 11 | 18 | 7 | 12 | 11 | 7 |
| Institute for Leadership and Organizational Management, Department of Leadership and Organizational Behaviour, Oslo, Norway | 75 | 0 | 1 | 4 | 10 | 26 | 9 | 6 | 8 | 7 | 2 | 2 |
| American University, Kogod School of Business, Washington, United States | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 18 | 22 |
| George Washington University, Department of Decision Sciences, Washington, United States | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 18 | 22 |
| BI Norwegian Business School, Oslo, Norway | 53 | 0 | 0 | 1 | 4 | 5 | 18 | 7 | 4 | 5 | 7 | 2 |
| Universidad de Castilla-La Mancha, Alarcos Research Group, Ciudad Real, Spain | 39 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 7 | 1 | 9 | 17 |

than or equal to an "h" number of citations (HIRSCH, 2005). Thus, from the h-index an author's productivity can be quantified by showing the impact they have in a general context on the scientific community. A connection between this indicator and the number of the authors' citations can be noticed, since those with the highest number of citations showed higher h-index.

During the analysis of Table 3 it was found out that the 10 authors who have their most cited work as articles on maturity model, turned out to be also prominent in the scientific community in a variety of research subjects, and several of them possess a vast amount of publications and citations. Thereby, the scientific research on maturity model that has been done based on the articles developed by these authors are assumed as righteous and reliable.

## Identifying scientific gaps

Table 5 presents the scientific gaps in the most recent articles on maturity model written by those most cited authors. Some of the most cited authors engaged in a joint effort for the preparation of the most recent articles on maturity model.

(1) Lockamy and McCormack have written their last article on maturity model in 2004, "The development of the supply chain management process maturity model using the concepts of business process orientation", published in the Supply Chain Management journal. In it, they propose the use of the measurements obtained through the supply chain maturity to improve the points where the maturity measurements fall short.

The research conducted by Lockamy and McCormack presents the use of the maturity model for the supply chain through a carefully evaluated table, which was well-grounded in a prime theoretical reference, and suggests that the performance of the supply chain obtained by SCOR (Supply Chain Operations Reference) is strongly related to the maturity of the supply chain.

The research indicates that direct performance measures, such as cycle times and inventory levels, are closely related to the supply chain maturity. All these connections suggest that the measurements of the supply chain maturity can be used to improve those points where the maturity measurements fall short.

Nevertheless, the measurement method of overall performance used in this research is not enough, and further clarification is needed in future studies, as well as an investigation of the supply chain maturity and financial measures.

(2) In their article, Wilson, Niazi and Zowghi identifies as scientific gap the need to improve the implementation framework of maturity model that contains three components: the SPI implementation plan (software process improvement), the SPI implementation script and the SPI implementation model.

A maturity model for the SPI implementation (software process improvement) is presented, so it could help companies evaluate and improve their SPI implementation processes. This research's model is extracted from CMMI (capability maturity model integrity), based on CSFs (critical success factors) and some critical barriers are identified through a literature review and an empirical study.

To develop this model, experiences, opinions and the views of professionals were analyzed in order to identify the factors that positively and negatively impact on the SPI

**Table 5** The scientific gaps identified in the recent articles on maturity model of the most cited authors

| Author | Co-authors | Last paper on maturity model | Year | Journal/FI (SJR) | Scientific gap |
|---|---|---|---|---|---|
| Lockamy,A | McCormack, K. | (1) The development of a supply chain management process maturity model using the concepts of business process orientation | 2004 | Supply Chain Management/ 1.931 | The authors propose the use of the measurements obtained through the supply chain maturity to improve points where the maturity measurements fall short |
| McCormack, K. | Lockamy,A | The development of a supply chain management process maturity model using the concepts of business process orientation | 2004 | Supply Chain Management/ 1.931 | [a] The authors propose the use of the measurements obtained through the supply chain maturity to improve points where the maturity measurements fall short |
| Wilson, D. | Niazi, M.K., Zowghi, D. | (2) A maturity model for the implementation of software process improvement: An empirical study | 2005 | Journal of Systems and Software/ 1.381 | The recommendation is to improve the implementation framework containing three components: implementation plan of the SPI, the SPI implementation script and its implementation model. A better assessment model can be suggested |
| Niazi, Mahmood K. | Wilson, D., Zowghi, D. | A maturity model for the implementation of software process improvement: An empirical study | 2005 | Journal of Systems and Software/ 1.381 | [a] The recommendation is to improve the implementation framework containing three components: implementation plan of the SPI, the SPI implementation script and its implementation model. A better assessment model can be suggested |
| Zowghi, Didar | Niazi, M.K., Wilson, D | A maturity model for the implementation of software process improvement: an empirical study | 2005 | Journal of Systems and Software/ 1.381 | [a] The recommendation is to improve the implementation framework containing three components: implementation plan of the SPI, the SPI implementation script and its implementation model. A better assessment model can be suggested |
| Gottschalk, Petter | – | (3) Maturity model for email communication in knowledge organizations: the case of police investigations | 2008 | International Journal of Law, Crime and Justice/0.249 | The authors suggest an empirical study in order to test the model's proposed stages, checking the performance of the police investigation when adopting the ideal measure in the communication via e-mail phase |
| Lee, Gwanhoo | Kwak, Y.H. | (4) An Open Government Maturity Model for social media-based public engagement | 2012 | Government Information Quarterly/1.203 | As a future work, the author suggests that the model is rigorously validated through the use of quantitative empirical data and incorporate the public perspective to the model |

**Table 5** continued

| Author | Co-authors | Last paper on maturity model | Year | Journal/FI (SJR) | Scientific gap |
|---|---|---|---|---|---|
| Solli-Sæther, Hans | Gottschalk, P. | (5) Maturity model for IT outsourcing relationships | 2006 | Industrial Management and Data Systems/0.846 | Search carefully for other existing phases in an IT outsourcing relationship, develop and explain the important issues at each stage and clarify the theoretical and empirical contributions that makes of the research more than just a scientific contribution |
| Kwak, Young Hoon | Lee, G. | An Open Government Maturity Model for social media-based public engagement | 2012 | Government Information Quarterly/1.203 | [a] As a future work, the author suggests that the model is rigorously validated through the use of quantitative empirical data and incorporate the public perspective to the model |
| Piattini, Mario | Garzás,J., Pino, F. J., Fernández, C.M. | (6) A maturity model for the Spanish software industry based on ISO standards | 2013 | Computer Standards and Interfaces/0.744 | Enhance the development of an organizational maturity model for the software industry in Spain |

[a] Identical scientific gaps, since they refer to the same article

implementation, however the authors of this study emphasize the need for improvement and a better evaluation of the model.

The authors should review the model in the future based on feedback from different practitioners and formulate a new version of it, then a case study will be conducted in order to validate and test the model in a practical way. Based on both the maturity model and the empirical study, the purpose is the structuring of an implementation framework consisting of three components: implementation plan of the SPI, the SPI implementation script and its implementation model. Theoretically, this paper presents only one component, namely the SPI implementation script.

The implementation framework is in its early stages and needs to be improved, so that a case study could be undertaken in order to test and validate it, as well as point out which aspects need to be adjusted.

(3) Gottschalk wrote his last article on maturity model in 2008 on the International Journal of Law, Crime and Justice under the title: "Maturity model for email communication in knowledge organizations: The case of police investigations". This article proposes a maturity model to the communication via email within a work environment in order to help organizations focus on e-mail as a tool, so that the benefits exceed costs and damages.

The model has four stages: person-technology, person–person, person-information and person-application. The author suggests a future empirical study testing the stages proposed in this model, checking the investigation performance while taking the appropriate action in the communication via email phase, which could be stated as the work's scientific gap.

It is acknowledged the necessity to constantly check whether the stages or levels used in maturity models are consistent with the process which the model is being prepared for, so that an effective maturity model could be obtained.

(4) Lee and Kwak published their last article on maturity model in 2012 on the Government Information Quarterly, with the title "An Open Government Maturity Model for social media-based public engagement". The research suggests the existence of different levels of maturity to achieve a government with greater public engagement.

They propose that, when moving from one maturity level to the next one in an orderly manner, governmental agencies can avoid unnecessary risks and systematically build its open-government capabilities, enabling both public and private sectors to participate, collaborate and innovate together.

The model, which was validated through a focus group and several field interviews, is mostly based on the perspective of the governmental agency. Therefore, the author suggests that in a future work the model be rigorously validated through the use of quantitative empirical data, and incorporates the public perspective.

The maturity model developed by Lee and Kwak is based largely on the government's perspective, so future research should be based on the perspectives of the public. The authors claim that there are situations where the existing linearity in the elaborated model would not bring the expected practicality due to other factors that might influence it, such as political, organizational and financial ones.

That way, some agencies will not use this model in its totality, requiring adjustments to meet specific needs. Thus, it is necessary a reformulation of the model by examining how

government agencies were able to manage certain existing tensions prior to their drafting, and, finally, how to customize the maturity model for more specific conditions.

(5) Gottschalk was co-author of the last publication of Solli-Sæther on maturity model, published in 2006 on the Industrial Management and Data System journal, under the title "Maturity model for IT outsourcing relationships". This research presents a maturity model for IT outsourcing based on organizational theories and practices, identifying three stages of maturity: cost, resource and partnership.

The analyzed variables for each stage were: economic benefits, primary transactions, contractual completeness, vendor behavior control, demarcation of labor, core competence management, vendor resource exploitation, relationship exploitation, social exchange exploitation, and stakeholder management.

According to Solli-Sæther, the research has several shortcomings that should be addressed in future research, for example: carefully check out for other existing phases in an IT outsourcing relationship, develop and explain the important issues at each stage and clarify the theoretical and empirical contributions that make of the research more than only a scientific contribution.

In order to validate the model stages, it is necessary to show that the transition occurs by their means, that is, to empirically demonstrate that most relationships will evolve toward cost-resources–partnership. A scientific gap is then identified: the necessity of measuring the model's reference variables, to which the authors suggest the use of the Guttman scale.

(6) Piattini was the latest to publish an article on maturity model, with the theme "The maturity model for the Spanish software industry based on ISO standards". Piattini has Garzas, Pino and Fernandez as co-authors and they identified the improvement of the development of an organizational maturity model for the software industry in Spain as a scientific gap.

This study presents the use and adaptation of some ISO models in the development of an organizational maturity model for the software industry in Spain, in order to minimize the deficiencies found in small software development companies by implementing models that are most widely used in large organizations.

With the development of the project to build the model, an application was initially performed in 16 Spanish companies belonging to AENOR (Spanish Association for Standardization and Certification) to obtain certification. According to the author, by 2013 approximately 38 companies have already obtained levels 2 and 3 certifications and several others were awaiting certification until the next year.

Arising from the need for an international ISO certification for process improvement in the organizational maturity level, the model presented in this article has been created, which evaluates software processes through maturity levels. The proposed model, based on ISO standards, is specific to small Spanish companies in the software industry, aiming to minimize the problems that occurred when process improvement models directed to large companies were implemented, such as CMMI-DEV (Capability Maturity Model-Integration for Development).

The proposed model has the advantage of not being as expensive, neither as complex as the CMMI-DEV. To elaborate the model known as software engineering maturity model, AENOR has formed a group of researchers and professionals in software engineering to develop and apply a maturity model consisting of three components: (a) evaluation of the CMM, (b) the model of a software life cycle, and (c) audit process based on the standards ISO/IEC 15504, ISO/IEC 12207:2008 e ISO/IEC 17021.

For that reason, besides of fulfilling the scientific gap of enhancing the development of an organizational maturity model for the software industry in Spain, this article also brings a great incentive to researchers on maturity models, identifying how useful and effective they can be. The proposed maturity model has been developed in Spain and, according to the authors, it was well diffused across the region, thus it can be adapted to other regions and/or other business sectors.

## Conclusion

Through the bibliometric analysis on the topic "maturity model" it was possible to characterize the importance of the subject in the decade 2004–2014. Considering the research areas presented in the study, the subject has a comprehensive approach involving the exact, human and biological sciences. Moreover, the maturity model is widely employed in project management to promote continuous improvement, as well as being a theme in progress that has been gaining relevance in the scientific community.

From the bibliometric analysis on maturity model, it has been also observed that new models arise from formerly developed ones, acting as guides or examples to be followed, which are then adapted in order to meet the requirement of a specific area, process or system.

This paper presents a bibliometric analysis of the maturity model in a general manner, not specifically analyzing an area for the application of the model. It also brings into light the analysis of published articles during an extended period of time.

Authors who have been publishing on the subject have certain relevance in the scientific community, since they have a great number of publications in various areas, in addition to the remarkable amount of citations each one possesses. Therefore, the articles which have been published on the subject have a desirable reliability.

Through the identification of the scientific gaps, a focus on continuous as well as processes' and systems' improvement is noticed, in addition to other situations that may need to achieve a desirable maturity. For this identification to be performed, the most recent published article on maturity model of the most cited authors has been analyzed, and it has been perceived that the publishing years are not close to the current date. This occurrence supported the conclusion that these authors are often cited due to the relevance of their published articles to the academic community, bringing theoretical collaborations and new ideas of how to develop maturity models, while also demonstrating that they could be applied to various sectors.

This article may also assist researchers in pursuing ideas for future studies on maturity models, identifying which key points cannot be left incomplete in their research, as well as serve to identify if their studies are on the right path to bringing scientific collaborations to the academic community. Researchers wishing to deepen their knowledge on maturity models will be aware of the most relevant articles and most distinguished authors on the subject, making it easier the search for information.

As the main scientific contribution of this paper, the presentation of the theme of maturity model, its applications and its increasing importance yet to be explored in the scientific community could be enumerated, in the hope of encouraging further study and research on the subject. Some of the authors who had previously worked with bibliometric analyzes, namely Blagus et al. (2015), Rubem et al. (2015), Ellegaard and Wallin (2015), among others, did not presented detailed tables with citations evolution graphics, as well as tables identifying the articles' scientific gaps.

In relation to its main applied contribution is the identification and analysis of major studies that have contributed significantly to the scientific research, allowing and encouraging the subject adoption by various organizational sectors.

Due to the relatively novelty of the subject, a more intense analysis could not be performed since it would probably lack information. Up to this moment, this article portrays the sole bibliometric analysis for the theme "maturity model".

Finally, a future deeper analysis on the subject is suggested, covering areas of study separately or a bibliometric analysis on the topic related to a more specific model.

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