

Ranking business processes maturity by modified rembrandt technique with considering CMMI dimensions

Ahmad Jafarnejad Chaghooshi, Mohsen Moradi Moghadam*, Soheila Etezadi

Faculty of Management, University of Tehran, Tehran, Iran

(Received: 14 July, 2015; Revised: 23 September, 2015; Accepted: 29 September, 2015)

Abstract

An organization's value is substantiated by consistent, high quality processes engineered in its operations and the allocation of the limited resources to achieve the desired objective. Intrinsic to the development of a process are the articulation of a coherent workflow, identification of the optimal skillset required at each stage of the process, and commissioning of the right technology platform. However, processes need to evolve with perceptible changes in the customer mindset, new technologies, exponential growth needs, and the unrelenting pressure on cost reduction. More than ever, organizations today need to institutionalize continual process improvement to avoid the risk of receding into obsolescence. While organizations choose from a menu of process improvement models, it is important to assess the maturity of the end-to-end process and to identify potential gaps and tailored solutions critically and in order. The purpose of this paper is to evaluate and rank the maturity of processes in a consulting firm. To achieve this goal, a review of the literature related to the organization's process maturity models is provided and thereafter a comprehensive model including factors and confirmed indicators is presented. It continues to assess and discuss the maturity of processes in a consulting firm.

Keywords

Business process maturity models, Process management, Rembrandt techniques.

* Corresponding Author, Email: Moradi_Mohsen@ut.ac.ir

Introduction

Today, organizations are faced with increasing global competition and demanding customers, and employees reduce product life cycle and the acceptable response time. Competition in many industries is mainly on the basis of strategic assets and the ability to apply these assets. In the new business approach, many companies understand that the processes as strategic assets for improvement, evolution, and maturity are in need of development and investment (Lockamy and McCormack, 2004). There are many improvement programs for companies (TQM, 6Sigma, continuous improvement processes, etc.) to improve their operations; however, none of these programs specifically assess and improve processes. The assessment of business processes, where the processes is a key element in the success of the company, is considered to be particularly important (Estampe, Lamouri & BrahiDjellou, 2010). Lack of appropriate evaluation of the processes and process improvement decisions without proper analysis may lead to unfortunate results in time, money, and market position (Reyes and Giattchi, 2010). A model is needed to describe the areas of operations and assess the company's focus on improving performance (Reyes and Giattchi, 2010). Maturity models are among the models that have been proposed in this field.

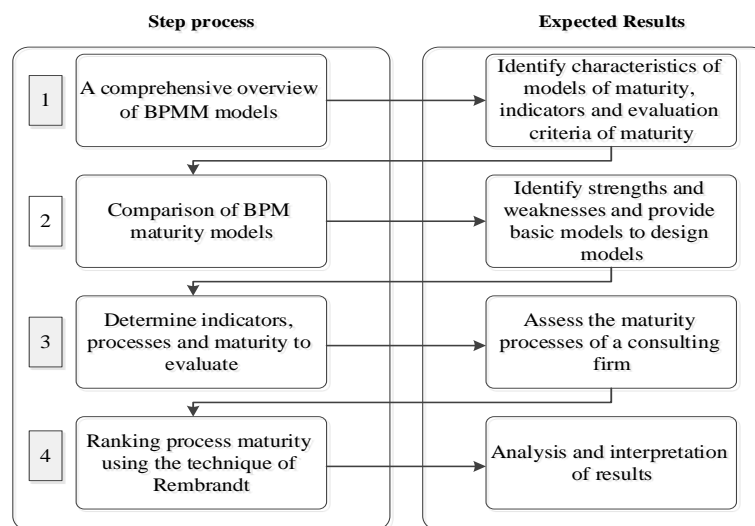


Fig. 1. Process research

Maturity models are used to assess as-is situations, to guide improvement initiatives, and to control progress (Iversen, Nielsen & Norbjerg, 1999). The aim of this study is to assess the maturity of business processes with the new framework. In order to achieve this goal, our research includes the following steps shown in Figure 1. The next Section provides an overview of the related literature on business process maturity models (BPMM). The proposed model is described in Figure 1. Finally, case study and the results are presented, and the maturity of the process is ranked by modified Rembrandt technique.

Theoretical background

Business processes

A process is a succession and related activities which create a particular product and for creating the product needs specific inputs that provide the grounds for building. Processes in any organization are designed to achieve the organization's mission to provide the basic needs of customers with better performance. Every process-oriented organization has a set of activities that require improvement for the success of the organization. Improving each process is a set of activities and decisions that are made in steps and a process of forming.

Foundations of maturity models

Based on the assumption of predictable patterns of organizational evolution and change, maturity models typically represent theories about how an organization's capabilities evolve in a stage-by-stage manner along an anticipated, desired, or logical path (Van den Ven and Poole, 1995; Gottschalk, 2009; Kazanjian and Drazin, 1989). Accordingly, they are also termed stages-of-growth models, stage models, or stage theories (Prananto, Mckay & Marshall, 2003). Early examples of maturity models refer to a hierarchy of human needs (Maslow, 1954), economic growth (Kuznets, 1965), and the progression of IT in organizations (Nolan, 1973, 1979). Nolan's stage hypothesis, for instance, stimulated much research that resulted in conflicting findings as regards its empirical validity (Prananto, Mckay

& Marshall, 2003). The corresponding stage model, however, has been widely adopted leading to hundreds of models based on a staged sequence of levels. Only few maturity models follow other structural designs (Fraser, Moultrie & Gregory, 2002; Rummler & Brache, 1990). The basic purpose of maturity models is to outline the stages of maturation paths. This includes the characteristics of each stage and the logical relationship between them (Kuznets, 1965). As for practical application, typical purposes of use (PoU) are descriptive, prescriptive, and comparative (de Bruin *et al.*, 2005). A maturity model serves a descriptive purpose if it can be applied for as-is assessments. It serves a prescriptive purpose if it indicates how to identify desirable future maturity levels and if it provides guidance on how to implement according to improvement measures. There are a variety of maturity models, some of which are discussed in Table 1.

Table 1. Business Process Maturity models referred to in the academic literature

Model	Scope	Year	Author
PPI (Process Performance Index)	BPM	1990,2004	Rummler & Brache (1994)
Business Process Orientation Maturity Model	BPM&P	2001	McCormack & Johnson (2001)
BPRMM (BPR Maturity Model)	BPM	2003	Mauil, Tranfield & Mauil (2003)
BPMM (BPM Maturity)	BPM	2004	Fisher (2004)
PML (Process Maturity Ladder)	BPM&P	2004	Harmon (2004)
BPRMM (BPR Maturity Model)	BPM	2005,2006	Rosemann & de Bruin (2005)
PEMM (Process and Enterprise Maturity Model)	BPM&P	2007	Hammer (2007)
BPMM (BPM Maturity)	BPM&P	2007	Lee, Lee & Sungwon (2007)
BPMM (BPM Maturity)	BPM&P	2008	Weber, Curtis & Gardiner (2008)
BPMA (BPM Assessment)	BPM&P	2009	Rohloff (2009)
Model for Business Process Maturity Assessment	BPM&P	2013	Moradi-Moghadam, Safari & Maleki (2013)

Comparison of maturity models

The following comparison of maturity models, based on the proposed

framework of Röglinger, Pöppelbuß and Becker (2012), is shown in Figure 2. In Table 2, we have compared some of the maturity models.

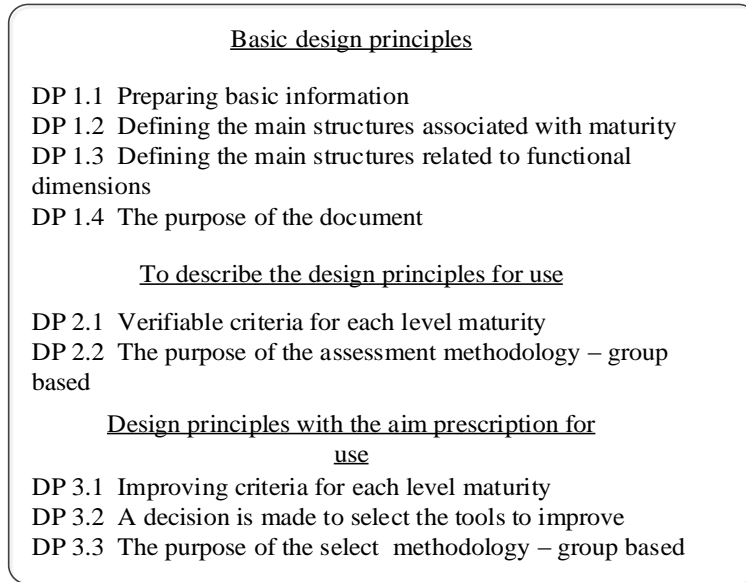


Fig. 2. Framework comparison of the maturity models (Röglinger, Pöppelbuß & Becker, 2012)

Table 2. Comparison of business process maturity models

Design Principles	Row	BPMMM	PPI	BPRMM	BPMM-Fisher
Basic Design Principles	DP1.1	Areas: Business Process Management, a business improvement plan to improve processes in the future. Evaluation is in as-is.	Areas: management processes in American companies, evaluates an organization's processes management. developed by Rummler and Brache	Mature business processes re-engineering projects, this model is part of the study, the company has implemented BPR project	Areas: mature business processes, organizational capabilities, particularly descriptive and prescriptive, to identify gaps and determine the measures to resolve them

Continue Table 2. Comparison of business process maturity models

Design Principles	Row	BPMMM	PPI	BPRMM	BPMM-Fisher
	DP1.2	6 steps, 5 factors with 5 areas of empowering the call is a theoretical model	Three stages of process management maturity, ten key success factors (KSF)	5 groups of companies with different maturity BPR projects	5 levels, 5 levels of change
	DP1.3	Business processes Management is as a measure of overall management.	Is not available	BPR; themes and dimensions of BPR, types of BPR projects	Is not available
	DP1.4	Research papers and PhD theses	Reports	Research paper	Paper trends in business processes
Design Principles with the aim of description	DP2.1	Conceptual descriptions of processes, factors, and areas of empowerment	The words ten key factors for success	Describes the concept of group	Conceptual description of levels
	DP2.2	Minor questions (evaluation kit) to assess the ability of each region publicly available.	Scorecard prepared, maturity levels have been determined based on a range of points.	Created experiences shared during the study.	Cell descriptions for each level in order to assess what is done.
Design Principles with the aim of prescription	DP3.1	Implicitly suggested for each level.	Not applicable.	Not applicable.	Referred to the cell descriptions
	DP3.2	Is not available	Not applicable.	Not applicable.	The gap between current and desired states to remove it.
	DP3.1	Is not available	Not applicable.	Not applicable.	Is not available

Proposed model for assessment of process maturity

In order to evaluate the maturity, the following steps are performed:

Determine the assessment process

This step should identify all organizational processes for assessment. In this research, to assess process maturity of an Iranian consulting

firm, we used porter framework for identification and classification (Appendix A).

Identify evaluation criteria of process maturity

To analyze the maturity of BPM within an organization, we constructed 7 dimensions of process maturity (Table 3). The maturity dimensions are based on the capability maturity model integration (CMMI) and research by Rosemann, de Bruin and Power (2004), Rosemann and de Bruin (2005) and Rosemann, de Bruin and Power (2006).

Table 3. BPM Maturity in Seven Dimensions

Number	Factors	Descriptions
C1	Process Awareness	Management realizes the importance of a process-oriented organization and includes this in its strategy
C2	process Description	Processes and related information within the organization are identified and captured in process descriptions
C3	Management of processes	A system to measure and control processes is in place in order to be able to improve processes
C4	Management of processes	Process owners who are “horizontally” responsible for managing processes are assigned within the organization
C5	process improvement	The organization strives to continually improve processes and there is a system in place to enable this.
C6	Research & Knowledge	The organization has adequate resources (such as people with process knowledge) to create a “culture of process orientation”
C7	Information Technology	The organization uses IT to design, simulate, and execute processes, and to provide real-time measurement information (key performance indicators)

Levels of maturity

The purpose of this step is to ensure that the choice of the base model (CMMI), in terms of stages of maturity has more integrity than the other models. Therefore, the comparison of models is shown in the Table 4.

Table 4. Comparison of basic research (CMMI) with other models

CMMI	BPMM	PML	BPRMM	BPMM	BPMA
Initial	Silo	Initial	Initial	Initial	Initial
Managed	Tactically integrated	Managed	Repeatable	Managed	Managed
Defined	Process driven	Defined	Defined	Defined	Defined
Quantitatively managed	Optimized enterprise	Quantitatively managed	Managed	Quantitatively managed	Quantitatively managed
Optimizing	Intelligent operating network	Optimizing	Optimizing	Optimizing	Optimizing

As noted in the previous section, most of the process management maturity and process maturity of authors, as well as the Capability Maturity Model

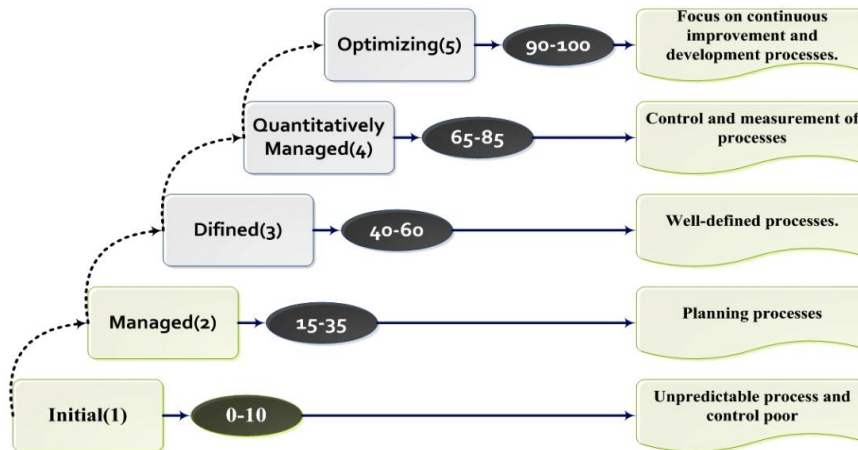


Fig. 3. The maturity level and scoring

Integration (CMMI) models have been fully described in previous chapters. Therefore, the comparison between process maturity models chosen for the model is illustrated in Figure 3 (Moradi-Moghadam, Safari & Maleki, 2013).

Research Methodology

When making decisions, decision-makers (DMs) will in most cases try to choose the optimal solution. Unfortunately, a true optimal solution only exists if you are considering a single criterion. In most real decision situations, basing a decision solely on one criterion is, however, insufficient. Probably several conflicting and often non-commensurable objectives should be considered. Therefore, it is impossible to find a genuine optimal solution, a solution which is optimal for all DMs under each of the criteria considered (Løken, 2007). Multi-criteria decision making (MCDM) is a generic term for methods that assist people in making decisions using their own preferences in cases where more than one conflicting criterion exists. Using MCDM can be said to be a way of dealing with complex problems by breaking the min to smaller pieces. After weighting

procedures and judgments of the smaller components, the pieces can be reassembled to present an overall picture to the DMs.

Another term used instead of MCDM is multi-criteria decision analysis (MCDA), where the use of 'analysis' instead of 'making' emphasizes that the method should assist the DMs in making decisions (as the method itself cannot make the decision). Hence, the aim of MCDA is to assist the DMs to choose, rank or sort alternatives within a finite set according to two or more criteria so that they feel comfortable with the final decision (Chen, Kilgour & Hipel, 2008). By using MCDA the DMs should feel that all important criteria have been properly accounted for, which should help to reduce the possibility of post-decision regret (Belton and Stewart, 2002).

Modified rembrandt technique

The original AHP by Saaty (1977) has been criticised for various reasons: 1) for the fundamental scale to quantify human judgments; 2) as it estimates the impacts scores of the alternatives by the Perron-Frobenius eigenvector; and 3) as it calculates the final scores of the alternatives using the arithmetic-mean aggregation rule. These controversial issues are well-known and not new. Already Zahedi (1986) signaled that the criticism of the AHP concentrated on the estimation of the impact scores, but that no major controversy existed concerning the aggregation step. Criticism of the fundamental scale was not mentioned by Zahedi, but Belton and Stewart (2002) brought forward several arguments against the scale and the aggregation rule.

A multiplicative version of the original AHP is available in form of the so-called Rembrandt (Ratio Estimations in Magnitudes or deci-Bells to Rate Alternatives which are Non-Dominated technique), see Lootsma (1992) and Olson *et al.* (1995). As for the original AHP the Rembrandt technique makes use of a structured hierarchical approach based on the principle that decision-makers make pairwise comparisons between alternatives to determine subjective impacts under each criterion in the assessment and between criteria in order to determine the irrelative importance. Finally, aggregating the results

leads to a final score for each project which allows a subjective rank ordering of the projects.

The systematic pairwise comparison approach is one of the cornerstones of the Rembrandt technique (Lootsma, 1992). Rembrandt makes use of a procedure for direct rating which requires the decision-makers to consider all possible pairs of alternatives with respect to each criterion in turn in order to determine which one of the projects in the pair is preferred and to specify the strength of preference according to a semantic scale (associated a numeric 0-8scale). The approach is, as mentioned, a multiplicative development of the AHP and it proposes to overcome the three issues regarding the theory behind AHP.

First, the direct rating in Rembrandt is on a geometric scale (Lootsma, 1992) which replaces Saaty's 1-9 original scale. Second, the eigenvector method originally used in AHP is replaced by the geometric mean method which avoids potential rank reversal (Barzilai, Cook & Golany, 1987). Third, the aggregation of scores by arithmetic mean is replaced by the product of alternative relative scores weighted by the power of weights obtained from the analysis of the hierarchical elements above the alternatives (Olson, Flidner & Currie, 1995).

In the use of the Rembrandt technique in this paper it is assumed that the ratifying group consists of g decision-makers ($g \geq 1$), and that at any stage of the process there are n alternatives ($n \geq 1$) under consideration. At the first evaluation level of the analysis, each pair of alternatives A_j and A_k is presented to the decision-makers under a specific criterion. The decision-makers are then asked to express their graded comparative judgment about them. In other words, the decision-makers express their indifference between the two, or a weak, definite, strong or very strong preference for one project over the other. Thus, at this stage the decision-makers are asked to make a standard $n(n-1)/2$ pairwise comparisons. Indeed, only $(n-1)$ properly chosen comparisons would be sufficient, for which reason the standard leads to much more information being collected than actually needed (Lootsma, 1992).

Such redundancy, however, is usually beneficial as it enables a smoothing of the results of the analysis. Incomplete pairwise comparisons in a group of decision-makers are handled in a general way by using Rembrandt, (see Lootsma, 1992); the case of complete pairwise comparisons by each and every one of the decision-makers is a special case. In this context it is assumed that alternative A_j and A_k have the same subjective values v_j and v_k for all decision-makers in a group. Using the Rembrandt technique, the group's agreed upon judgment about the pair A_j and A_k is taken to be an estimate of the preference ratio v_j/v_k .

The decision-makers' pairwise comparative judgment of A_j versus A_k is captured on a category scale to frame the range of possible verbal responses. This is converted into an integer-valued gradation index δ_{jk} according to the Rembrandt scale in Table 5. The number of categories is rather small as human beings' linguistic capacity to describe the categories unambiguously in verbal terms is limited (Lootsma, 1992).

Table 5. The Rembrandt scale (Lootsma, 1992)

Comparative judgment	Gradation index δ_{jk}
Very strong preference for A_k over A_j	-8
Strong preference for A_k over A_j	-6
Definite preference for A_k over A_j	-4
Weak preference for A_k over A_j	-2
Indifference	0
Weak preference for A_j over A_k	+2
Definite preference for A_j over A_k	+4
Strong preference for A_j over A_k	+6
Very strong preference for A_j over A_k	+8

Intermediate integer values can be assigned to δ_{jk} to express a hesitation between two adjacent categories. The gradation index δ_{jk} can be converted into a value on a geometric scale, characterised by a scale parameter $\gamma = \ln(1 + \epsilon)$, where $1 + \epsilon$ is the progression factor.

$$r_{jk} = \exp(\gamma \delta_{jk}), \quad j, k = 1, \dots, n$$

Thus r_{jk} is defined to be the numeric estimate of the preference ratio v_j/v_k . Although there is no unique scale of human judgment, a

plausible value of γ is $\ln(2)$ implying a geometric scale with the progression factor 2 (Lootsma, 1992).

There are five major, linguistically distinct categories in Table 3: indifference, weak, definite, strong and verystrong. Moreover, there are four so-called threshold categories between them which can be used if the decision-makers are in-between qualifications. Lootsma (1999) shows that human beings follow the same pattern in many unrelated areas when they categorize an interval, e.g., certain ranges on the time axis and sound and light intensities. Normally three to five major categories are introduced and the progression factor $\exp_{(2\gamma)=(1+\epsilon)^2}$ is roughly 4, see Lootsma (1992, 1999). By the interpolation of threshold categories, a more refined subdivision of the given interval is obtained. In that case there are six to nine categories and the progression factor $\exp_{(\gamma)=(1+\epsilon)^2}$ is roughly $2^{(\gamma=\ln 2)}$ 0.7), which defines what Lootsma (1993) calls the natural Rembrandt scale. In addition, Lootsma (1993) suggests that sensitivity analysis should be carried out with a short ($\gamma=0.5$) and a long ($\gamma=1.0$) geometric scale in the neighborhood of the natural scale. When determining criteria weights Lootsma (1999) finds the progression factor to be $\sqrt{2}$. The reason behind a lower progression factor may link to implicit trade-off consideration being more deliberate with criteria than is the case with scoring of alternatives.

Case study

This paper has been conducted in Ghos-Niroo Company that is a company active in the Consulting areas in Iran. In this paper, to assess Process Maturity, we have seven criteria that include Process Awareness (C1), Process Description (C2), Measurement of Processes (C3), Management of Processes (C4), Process Improvement (C5), Process Research & Knowledge (C6), and Information Technology (C7). In addition, we have 16 processes as alternatives that include strategic management and performance management (P₁), knowledge management (P₂) Quality, health, safety, and environment: QHSE (P₃) System design and method (P₄), marketing and sales (P₅),

supply management (P₆), engineering and consulting service (P₇), design, procurement and construction (P₈), management contract (P₉), investment project (P₁₀), human resource management (P₁₁), management of financial resource (P₁₂), asset management (P₁₃), management information and communication technology (P₁₄), management of external communications (P₁₅), management support services (P₁₆).

Ranking results

According to the proposed maturity model, assessing the company's processes maturity was based on level maturity in Figure 3 (scores are between 0 to 100). Its results are shown in Table 6.

Table 6. Maturity assessment results of process's Qods-Niroo company

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
P ₁	44.600	45.417	57.917	50.188	55.625	44.000	52.125
P ₂	44.700	41.583	49.667	47.875	40.875	37.625	40.438
P ₃	54.650	49.833	56.083	46.938	59.625	47.250	52.188
P ₄	40.900	37.417	45.667	41.625	41.250	38.750	40.813
P ₅	29.750	31.333	36.750	35.500	35.500	31.188	32.125
P ₆	36.800	32.417	43.250	40.250	38.250	35.813	38.125
P ₇	62.340	59.083	66.417	57.750	64.375	58.063	60.063
P ₈	31.750	29.083	38.583	35.563	27.500	31.313	32.000
P ₉	35.500	33.583	44.167	37.500	27.250	32.000	31.000
P ₁₀	29.100	27.083	37.667	33.813	25.500	27.063	27.063
P ₁₁	40.750	37.583	43.083	41.375	47.875	36.563	41.188
P ₁₂	44.500	37.917	48.167	41.875	48.125	35.938	43.250
P ₁₃	32.300	30.333	37.083	37.250	41.500	30.250	36.938
P ₁₄	42.750	39.167	46.750	47.063	54.625	42.125	45.813
P ₁₅	35.250	32.917	40.750	35.000	32.625	29.938	34.250
P ₁₆	51.200	46.083	56.417	52.313	64.500	45.938	50.438

After evaluating the processes of the company, we use Rembrandt technique with the difference that instead of using experts' opinions from the scores that were in Table 6, the scores of processes maturity are mutually compared, due to the high computing following the calculation processes for the criteria 1 (Table 7-8). Table 9 offers weighting technique for C1. The calculations are not continued.

Table 7. Scores of the maturity of corporate processes in modified Rembrandt technique for C1

C1	Compelled comparison(jkδ)															
	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	p16
p1	0.00	1.00	0.82	1.09	1.50	1.21	0.72	1.40	1.26	1.53	1.00	1.38	1.04	1.27	1.27	0.87
p2	-1.00	0.00	0.82	1.09	1.50	1.21	0.72	1.41	1.26	1.54	1.10	1.00	1.38	1.05	1.27	0.87
p3	-0.80	-0.80	0.00	1.34	1.84	1.49	0.88	1.72	1.54	1.88	1.34	1.23	1.69	1.28	1.55	1.07
p4	-1.10	-1.10	-1.30	0.00	1.37	1.11	0.66	1.29	1.15	1.41	1.00	0.92	1.27	0.96	1.16	0.80
p5	-1.50	-1.50	-1.80	-1.40	0.00	0.81	0.48	0.94	0.84	1.02	0.73	0.67	0.92	0.70	0.84	0.58
p6	-1.20	-1.20	-1.50	-1.10	-0.80	0.00	0.59	1.16	1.04	1.26	0.90	0.83	1.14	0.86	1.04	0.72
p7	-0.70	-0.70	-0.90	-0.70	-0.50	-0.60	0.00	1.96	1.76	2.14	1.53	1.40	1.93	1.46	1.77	1.22
p8	-1.40	-1.40	-1.70	-1.30	-0.90	-1.20	-2.00	0.00	0.89	1.09	0.78	0.71	0.98	0.74	0.90	0.62
p9	-1.30	-1.30	-1.50	-1.20	-0.80	-1.00	-1.80	-0.90	0.00	1.22	0.87	0.80	1.10	0.83	1.01	0.69
p10	-1.50	-1.50	-1.90	-1.40	-0.10	-1.30	-2.10	-1.10	-1.20	0.00	0.71	0.65	0.90	0.68	0.83	0.57
p11	-1.00	-1.10	-1.30	-1.00	-0.70	-0.90	-1.50	-0.80	-0.90	-0.70	0.00	0.92	1.26	0.95	1.16	0.80
p12	-1.40	-1.00	-1.20	-0.90	-0.70	-0.80	-1.40	-0.70	-0.80	-0.70	-0.90	0.00	1.38	1.04	1.26	0.87
p13	-1.00	-1.40	-1.70	-1.30	-0.90	-1.10	-1.90	-1.00	-1.10	-0.90	-1.30	-1.40	0.00	0.76	1.26	0.87
p14	-1.30	-1.00	-1.30	-1.00	-0.70	-0.90	-1.50	-0.70	-0.80	-0.70	-1.00	-1.00	-0.80	0.00	1.21	0.83
p15	-1.30	-1.30	-1.60	-1.20	-0.80	-1.00	-1.80	-0.90	-1.00	-0.80	-1.20	-1.30	-1.30	-1.20	0.00	0.69
p16	-0.90	-0.90	-1.10	-0.80	-0.60	-0.70	-1.20	-0.60	-0.70	-0.60	-0.80	-0.90	-0.90	-0.80	-0.70	0.00

Table 8. Scores of the maturity of corporate processes in modified Rembrandt technique for C1 (Conversion (γ=.7))

c1	Conversion(γ=.7)																GOEMEAN
	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10	p11	p12	p13	p14	p15	p16	
p1	1.00	2.01	1.77	2.15	2.86	2.34	1.65	2.67	2.41	2.92	2.02	2.63	2.08	2.42	2.42	1.84	2.1
p2	0.50	1.00	1.77	2.15	2.86	2.34	1.65	2.68	2.41	2.93	2.16	2.02	2.63	2.08	2.43	1.84	1.9
p3	0.57	0.57	1.00	2.55	3.62	2.83	1.85	3.34	2.94	3.72	2.56	2.36	3.27	2.45	2.96	2.11	2.1
p4	0.46	0.46	0.40	1.00	2.62	2.18	1.58	2.46	2.24	2.67	2.02	1.90	2.43	1.95	2.25	1.75	1.5
p5	0.35	0.35	0.28	0.38	1.00	1.76	1.40	1.93	1.80	2.05	1.67	1.60	1.91	1.63	1.81	1.50	1.1
p6	0.43	0.43	0.35	0.46	0.57	1.00	1.51	2.25	2.07	2.42	1.88	1.78	2.22	1.83	2.08	1.65	1.2
p7	0.61	0.61	0.53	0.61	0.70	0.66	1.00	3.95	3.42	4.48	2.92	2.67	3.86	2.78	3.45	2.35	1.6
p8	0.38	0.38	0.30	0.40	0.53	0.43	0.25	1.00	1.87	2.15	1.73	1.65	1.99	1.68	1.88	1.54	0.9
p9	0.40	0.40	0.35	0.43	0.57	0.50	0.28	0.53	1.00	2.35	1.84	1.75	2.16	1.79	2.02	1.62	0.9
p10	0.35	0.35	0.26	0.38	0.93	0.40	0.23	0.46	0.43	1.00	1.65	1.58	1.88	1.61	1.78	1.49	0.7
p11	0.50	0.46	0.40	0.50	0.61	0.53	0.35	0.57	0.53	0.61	1.00	1.90	2.42	1.95	2.25	1.75	0.8
p12	0.38	0.50	0.43	0.53	0.61	0.57	0.38	0.61	0.57	0.61	0.53	1.00	2.62	2.07	2.42	1.84	0.8
p13	0.50	0.38	0.30	0.40	0.53	0.46	0.26	0.50	0.46	0.53	0.40	0.38	1.00	1.70	2.42	1.84	0.6
p14	0.40	0.50	0.40	0.50	0.61	0.53	0.35	0.61	0.57	0.61	0.50	0.50	0.57	1.00	2.34	1.79	0.6
p15	0.40	0.40	0.33	0.43	0.57	0.50	0.28	0.53	0.50	0.57	0.43	0.40	0.40	0.43	1.00	1.62	0.5
p16	0.53	0.53	0.46	0.57	0.66	0.61	0.43	0.66	0.61	0.66	0.57	0.53	0.53	0.57	0.61	1.00	0.6

Table 9. Weighting technique for processing of Rembrandt

	Compelled comparison (jkδ)							Conversion (γ=.7)							GEOMEAN	NORMAL
	c1	c2	c3	c4	c5	c6	c7	c1	c2	c3	c4	c5	c6	c7		
c1	0	1.07	0.87	0.96	0.93	1.08	1.00	c1	1	2.12	1.84	1.96	1.92	2.14	1.8	0.3
c2	-1.07	0.00	0.82	0.90	0.87	1.01	0.93	c2	0.47	1.00	1.77	1.87	1.83	2.03	1.3	0.2
c3	-0.87	-0.82	0.00	1.10	1.06	1.24	1.14	c3	0.54	0.56	1.00	2.16	2.10	2.38	1.2	0.2
c4	-0.96	-0.90	-1.10	0.00	0.97	1.13	1.04	c4	0.51	0.53	0.46	1.00	1.97	2.20	0.9	0.1
c5	-0.93	-0.87	-1.06	-0.97	0.00	1.17	1.07	c5	0.52	0.55	0.48	0.51	1.00	2.26	0.7	0.1
c6	-1.08	-1.01	-1.24	-1.13	-1.17	0.00	0.92	c6	0.47	0.49	0.42	0.45	0.44	1.00	0.5	0.1
c7	-1.00	-0.93	-1.14	-1.04	-1.07	-0.92	0.00	c7	0.50	0.52	0.45	0.48	0.47	0.53	0.5	0.1

After comparing coupling processes based on each criterion, the following criteria are rated based on the information of Table 6 and the final weight assigned to each criterion. Using the numbers from the previous tables and the formula to rank the processes, we have:

$$w_j = \prod_{i=1,k} w_i^{o(i)} \tag{1}$$

For example of process 1 = $2.1^{0/3} \times 2.3^{0/2} \times 2.3^{0/2} \times 2.2^{0/1} \times 2.2^{0/1} \times 2.4^{0/1} = 2.4$

Table 10. The final ranking of each of the processes

	Ranking	
p1	2.4	1
p2	2	2
p3	1.37	4
p4	1.57	3
p5	1.2	5
p6	1.19	7
p7	1.67	6
p8	0.88	8
p9	0.85	9
p10	0.68	13
p11	0.79	10
p12	0.74	11
p13	0.57	14
p14	0.69	12
p15	0.46	15
p16	0.69	12

Conclusion

This model can be used by companies in order to improve their

efficiency, decreases costs, and customer satisfaction, and to grow the top line and achieve competitive advantages. These advantages become more visible as the company progresses. On the flip side, companies will find themselves in a disadvantageous state if they do not progress, as their competitors will likely be trying to accomplish this same feat. Ultimately, to climb the mountain and realize these benefits, companies must understand that there will be high hurdles to overcome at each step of the way. Our research tries to fill this gap by conducting a comparative study on popular models.

This paper examines the maturity model business processes and then identifies indicators with a comprehensive overview carried out on the factors affecting the maturation process. The maturity assessment process of the proposed technique was done on an Iranian consulting firm. Based on the results of the strategic management processes and performance management, knowledge management, change and improvement of the process of engineering and consulting services have had the highest level of maturity and external relations of management processes and asset management have had the lowest maturity. The results show how the company's maturity rates the optimal maturity level, and demonstrate that the company should strive to achieve a higher maturity level.

Limitation and future research

This research tried to demonstrate framework for companies in order to improve their efficiency process, but for deeper insights for the managers and also related researchers of the field, it needs to be applied to other companies, too. Unfortunately, there are not enough studies in this field.

Since this research is an applied study, so it is recommended that future researchers survey enterprise maturity models and design a novel model for assessing maturity. Due to limitation of accountability to scientific databases, it may investigate other criteria and indexes to evaluate processes maturity.

References

- Barzilai, J.; Cook, W. & Golany, B. (1987). "Consistent weights for judgment matrices of the relative importance for alternatives". *Operations Research Letters*, 6(3), 131-134.
- Belton, V. & Stewart, T.J. (2002). *Multiple Criteria Decision Analysis: An Integrated Approach*. Kluwer Academic Publishers, Massachusetts.
- Chen, Y.; Kilgour, D.M. & Hipel, K.W. (2008). "Screening in multiple criteria decision analysis". *Decision Support Systems*, 45(2), 278-290.
- De Bruin, T.; Rosemann, M.; Freeze, R. & Kulkarni, U. (2005). "Understanding the main phases of developing a maturity assessment model". In *ACIS 2005 Proceedings - 16th Australasian Conference on Information Systems*, Sydney.
- Estampe, D.; Lamouri, S. & BrahiDjellou, S. (2013). "A framework for analyzing supply chain performance evaluation models". *International Journal of Production Economics*, 142(2), 247-258.
- Fisher, D.M. (2004). "The business process maturity model: a practical approach for identifying opportunities for optimization". *Business Process Trends*, 9(4), 1-7.
- Fraser, P.; Moultrie, J. & Gregory, M. (2002). "The use of maturity models/grids as a tool in assessing product development capability: A review". *IEEE International Engineering Management Conference*, Cambridge.
- Gottschalk, P. (2009). "Maturity levels for interoperability in digital government". *Government Information Quarterly*, 26(1), 75-81.
- Hammer, M. (2007). "The Process Audit". *Harvard Business Review*, 85(4), 111-23.
- Harmon, P. (2004). "Evaluating an Organization's Business Process Maturity". *Business Process Trends*, 2(3), 1-11.
- Iversen, J.; Nielsen, P.A. & Norbjerg, J. (1999). "Situating Assessment of Problems in Software Development". *Database for Advances in Information Systems*, 30(2), 66-81.
- Kazanjian, R.K. & Drazin, R. (1989). "An Empirical Test of a Stage of Growth Progression Model". *Management Science*, 35(12), 1489-503.
- Kuznets, S. (1965). *Economic Growth and Structure*. Heinemann Educational Books, London.
- Lee, J.; Lee, D. & Sungwon, K. (2007). *An Overview of the Business Process Maturity Model (BPMM)*. International Workshop on Process Aware Information Systems (PAIS 2007), Springer, Huang Shan (Yellow Mountain).

- Lockamy III, A. & McCormack, K. (2004). "The development of a supply chain management process maturity model using the concepts of business process orientation". *Supply Chain Management: An International Journal*, 9(4), 272–278.
- Løken, E. (2007). "Use of multicriteria decision analysis methods for energy planning problems". *Renewable & Sustainable Energy Reviews*, 11(7), 1584-1595.
- Lootsma, F.A. (1992). *The Rembrandt system for multi-criteria decision analysis via pairwise comparisons or direct rating*. Report 92-05, Faculteit der Technische Wiskunde en Informatica. Delft University of Technology, Netherlands.
- Lootsma, F.A. (1993). "Scale sensitivity in the multiplicative AHP and SMART". *Journal of MultiCriteria Decision Analysis*, 2(2), 87-110.
- Lootsma, F.A. & Bots, P.W.G. (1999). "The assignment of scores for output-based research funding". *MultiCriteria Decision Analysis*, 8(1), 44-50.
- Maslow, A. (1954). *Motivation and Personality*, Harper, New York, NY.
- Mauil, R.S.; Tranfield, D.R. & Mauil, W. (2003). "Factors characterizing the maturity of BPR programs". *International Journal of Operations & Production Management*, 23(6), 596-624.
- McCormack, K. & Johnson, W. (2001). *Business Process Orientation: Gaining the E-business Competitive Advantage*. St Lucie Press, Delray Beach, FL.
- Moradi-Moghadam, M.; Safari, H. & Maleki, M. (2013). "A novel model for business process maturity assessment through combining maturity models with EFQM and ISO 9004:2009". *International Journal of Business Process Integration and Management*, 6(2), 167–184.
- Nolan, R.L. (1973). "Managing the computer resource: a stage hypothesis". *Communications of the ACM*, 16(7), 399-405.
- Nolan, R.L. (1979). "Managing the crisis in data processing". *Harvard Business Review*, 57(2), 115-26.
- Olson, D.L.; Fliedner, G. & Currie, K. (1995). "Comparison of the REMBRANDT system with analytic hierarchy process". *European Journal of Operational Research*, 82, 522-539.
- Prananto, A.; Mckay, J. & Marshall, P. (2003). "A study of the progression of e-business maturity in Australian SMEs: Some evidence of the applicability of the stages of growth for e-business model". *7th Pacific Asia Conference on Information Systems (PACIS)*, Adelaide.
- Reyes, H.G. & Giachetti, R. (2010). "Using experts to develop a supply chain maturity model in Mexico". *Supply Chain Management: An International Journal*, 15(6), 415-424.

- Roeglinger, M.; Poepelbuss, J. & Becker, J. (2012). "Maturity models in business process management". *Business Process Management Journal*, 18(2), 328–346.
- Rohloff, M. (2009). "An approach to assess the implementation of business process management in enterprises". *Paper presented at 17th European Conference on Information Systems (ECIS 2009)*, Verona.
- Rosemann, M.; de Bruin, T., & Power, B. (2006). "A model to measure BPM maturity and improve performance". In: Jeston J, Nelis J (eds) *Business process management: Practical guidelines for successful implementation*. Elsevier, Oxford.
- Rosemann, M.; de Bruin, T. & Hueffner, T. (2004). "A Model for Business Process Management Maturity". www.bpm.fit.qut.edu.au.
- Rosemann, M. & de Bruin, T. (2005). "Towards a business process management maturity model". *13th European Conference on Information Systems (ECIS)*, Regensburg.
- Rummler, G. & Brache, A. (1990). *Improving Performance: How to Manage the White Space on the Organization Chart*. Jossey-Bass, San Francisco, CA.
- Saaty, T.L. (1977). "Scenarios and priorities in transport planning: Application to the Sudan". *Transport Research*, 11(5), 343-350.
- Van den Ven, A.H. & Poole, M.S. (1995). "Explaining development and change in organizations". *Academy of Management Review*, 20(3), 510-40.
- Weber, C.; Curtis, B. & Gardiner, T. (2008). *Business Process Maturity Model (BPMM) Version 1.0*. available at: (<http://www.omg.org/spec/BPMM/1.0/>)
- Zahedi, F. (1986). "A Simulation Study of Estimation Methods in the Analytic Hierarchy Process". *Socio-Economic planning Sciences*, 20(6), 347-354.

Appendix a) Abbreviation table and Process map

Abbreviation	Word
BPMM	Business Process Maturity Model
PPI	Process Performance Index
BPRMM	BPR Maturity Model
PML	Process Maturity Ladder
BPRMM	BPR Maturity Model
PEMM	Process and Enterprise Maturity Model
BPMA	BPM Assessment
CMMI	Capability Maturity Model Integration
MCDM	Multi-Criteria Decision Making
MCDA	Multi-Criteria Decision Analysis
DMS	Decision-Makers
Rembrandt	Ratio Estimations in Magnitudes or deci-Bells to Rate Alternatives which are Non-Dominated technique

