ASSESSING RISK AND UNCERTAINTY: A COMBINED APPROACH BASED ON AHP METHOD

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ABSTRACT
A successful organization recognizes that when an effective strategy is properly implemented, it will result in a sustainable competitive advantage. But when you examine the formulation of an organizational strategy, you quickly realize that strategy is really about choice.
In this context project risk management based on Analytical Hierarchy Process (AHP) approach is a systematic process of identifying, analyzing and responding to risks manage. This paper presents the Analytical Hierarchy Process (AHP) as a potential decision making method in project risk management field. The final aim of our work is to define a model for evaluating the performance of product development in order to measure their achievement and activate pathways for improvement.

Keywords: project risk management, , decision support system, AHP, competitive advantage

1. INTRODUCTION

The competitiveness in global and local markets highlights the importance of design, quality, productivity, multi-company collaboration, optimal price levels and production process predictability (Susterova *et al.,* 2012). When an industrial company launches a new product at the market the goal is to obtain a viable business (Longo *et al.,* 2012).

Acceptable levels of product qualities such as safety, performance, reliability and security are critical successful factors. Acceptable levels include maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives (Dey, 2001). We sought to address the following research question: *How can appropriate performance strategies be selected and integrated into process models that target a specific product quality?*

The success parameters for any project are on time completion, within specific budget and with requisite performance (technical requirement). It is necessary to develop strategies and measures to manage these risks (Chapman, 2006).

As the interval of technical innovation cycles has become shorter, the life cycle of products has been shortened. Due to the diversification of customer needs, the functions and performance of products should be improved quickly.

In the past, a number of systematic frameworks have been proposed for use in the risk-evaluation phase of the risk management process. Kangari and Riggs (Kangari and Riggs, 1989) classified these methods into two categories: *classical models* (i.e. probability analysis and Monte Carlo simulation), and *conceptual models* (i.e. fuzzy-set analysis).

In fact diverse risk factors that occur during product development are obstacles for the successful development of new products. From this point of view, project risk management is faced with decision environments and problems in projects that are complex. Relationships between elements of a problem may be highly nonlinear; changes in the elements may not be related by simple proportionality (Kwak and Anbari, 2009).

Project risk is an uncertain event, feature, activity or situation that can have a positive or negative effect on the outcome of a project. Project risk and opportunity management formally identifies, assesses and plans for uncertainty. Many studies on risk analysis and management have been performed, but systematic research on how a risk management system is built has been rare (Park *et al.,* 2011).

In this paper, a *decision support tool* method is proposed, to help development teams choose appropriate quality performances across the lifecycle.

This is based on three perspectives: *product-quality-risk management, process integration and cost/benefit*.

Decision making is difficult enough as it is, especially when decisions you are making are based on incomplete information, uncertainty, and lack of freely available resources. If you combine those difficulties with an approach to decision making that is unstructured, inefficient, personality driven, and full of analysis paralysis, you will definitely not get the outcomes you want. This quandary is compounded when the types of decisions you are making are predictive in nature since you may not know for years if choices you make today are wise or foolish (De Felice and Petrillo, 2009).

At every stage of the decision making process, misperceptions, biases, and other tricks of the mind can influence the choices we make. Highly complex and important decisions are the most prone to distortion because they tend to involve the most assumptions, the most estimates, and the most inputs from the most people (Poveda-Bautista *et al.*, 2013). Since there are few scientific risk management systems available for new product development to predict risk factors and to prepare for responding activities against each risk factor, in the present paper a combined approach based on a particular multicriteria decision-making method (MCDM) called Analytic Hierarchy Process (AHP), is applied to weigh the degree of importance of the strategies identified.

We present a proposed method and validation from an industry case study. The paper is organized in the following way: Section 2 discusses work related to this research and identifies the gaps of knowledge in the area of project risk management. Section 3 elaborates the methodology for the research based on AHP. Section 4 introduces the conceptual framework of the methodological approach. Section 5 demonstrates the application of the proposed framework. Section 6 provides a detailed discussion and conclusion on the application of the proposed framework.

2. RISK MANAGEMENT AND PRODUCT DEVELOPMENT PERFORMANCE

Product development projects should include also risk assessment, that allows managers to identify and measure the risks associated with resource constraints and then develop appropriate responses (Bruzzone *et al.*, 2008). Many studies on risk analysis and management have been performed, but systematic research on how a risk management system is built has been rare. In particular, there are few systematic studies on the establishment of risk management systems for new product development (Cooper, 2003).

Desired product quality attributes can be achieved by using specific processes. Appropriate techniques, methods and tools can be applied to analyse, avoid, reduce, minimise and eliminate the risks related to products development. Jones *et al.* emphasizes that the risk management process must be an integral part of the quality management system. Management literature from various perspectives contains empirical and theoretical discussions of how firms develop new products. Although differences in emphases exist, especially with regard to how researchers believe firms should generate new product ideas or manage this process, overall, there is a surprisingly wide area of agreement (Cusumano and Nobeoka, 1991).

Product development is view as problem solving that needs to understand user (market) needs and then match these needs with the capabilities of particular technologies, rather than letting technology overly influence the development process (Schmidt and Calantone, 2002).

Figure 1 outlines the framework used in this article to analyze major features for product-development strategy.

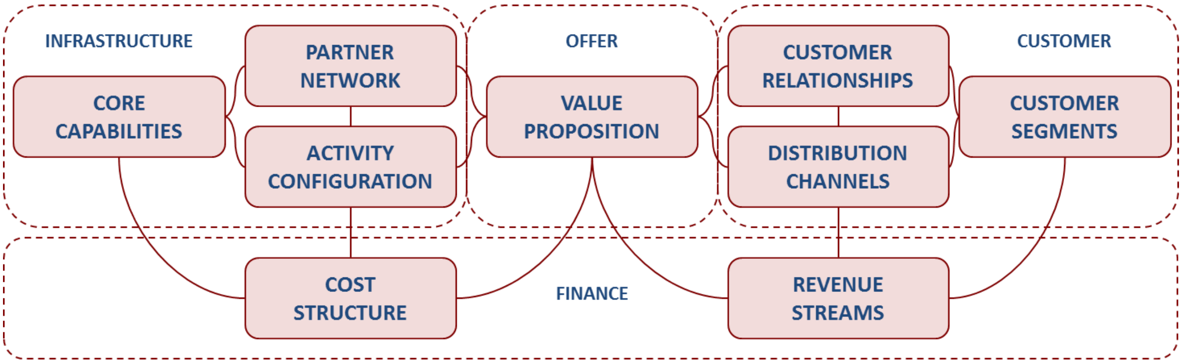

Figure 1: Organizational model

The above model describes the value an organization offers to various customers and portrays the capabilities and partners required for creating, marketing, and delivering this value and relationship capital with the goal of generating profitable and sustainable revenue streams.

3. THE ANALYTICAL HIERARCHY PROCESS (AHP)

A product is a set of benefits offered for exchange and can be tangible (that is, something physical you can touch) or intangible (like a service, experience, or belief) (Karnie and Reich, 2011).

We apply concepts from risk management to accommodate multiple quality attributes.

Numerous multicriteria decision making (MCDM) methods have been developed to help with decision problems by evaluating a set of candidates against pre-specified criteria. Examples of MCDM include Multi-Attribute Utility Theory (MAUT) (Keeney and Raiffa, 1993), AHP (Saaty, 1980), outranking techniques (Roy, 1996), weighting techniques (Keeney, 1999) and fuzzy techniques (Fuller and Carlsson, 1996).

In this research, we apply AHP. It is widely used for many practical decision-making problems in industry and academia. The decision-making process in AHP is based on relative assessment. In AHP, all candidates are evaluated using pairwise comparisons. As a result, the evaluation is less sensitive to judgment errors when compared to other MCDM methods using absolute assignments.

AHP method is based on three fundamental principles: *decomposition of the structure, comparison of judgments and hierarchical composition* (or synthesis) of priorities. AHP is applicable to decision situations involving subjective expert judgments and uses both qualitative and quantitative data. This method creates a priority index for each expert decision or judgment. AHP summarizes these judgments by ensuring their consistency.

The proposed approach involves the AHP method for the paired comparison of the risk factors, which was carried out. AHP allows to:

- Facilitate key decision makers to identify relevant criteria;
- Provide an approach to weight decision criteria and objectives
- Identify the best choices from a set of potential alternatives
- Allocate critical resources to "best-value" projects
- Generate advanced portfolio analysis reports: risk and "what-if" scenarios.

The main results that can be achieved are:

- Rapidly achieve consensus and buy-in to decisions.
- Make more informed decisions that can adjust and you or your environment changes.
- Improve transparency of key decisions by provide a repeatable method of tracking, auditing and improving decisions over time.

The strength of this approach is that it organizes tangible and intangible factors in a systematic way, and provides a structured yet relatively simple solution to the decision-making problems (Al-Harbi, 2001). Then over time, the project portfolio could be optimized as the needs of the business change.

The Analytic Hierarchy Process enables decision makers to structure decisions hierarchically: the goal of the decision at the top, strategic objectives in the higher levels, evaluation criteria in the middle, and alternative choices at the bottom (as shown in Figure 2).

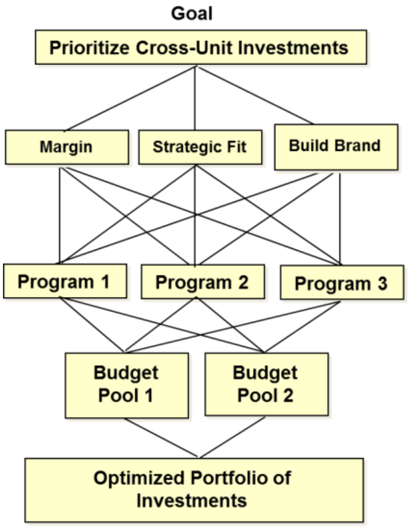

Figure 2: Sample of hierarchy

We establish a relative order of importance for business process improvement projects based on this four-step process:

1. Develop a hierarchy of business drivers and criteria—from high level drivers at the top to more specific criteria that will be used to measure the value of projects.
2. Compare business drivers, then use decision criteria to determine their priorities in helping the organization be successful.
3. Rate projects against the criteria using accurate numerical scales derived through pairwise comparisons.
4. Optimize the allocation of resources (human and financial) by maximizing value for cost based on well-understood business rules (interdependencies, must fund projects, time based allocations). This can be accomplished using linear and integer optimization techniques.

AHP creates a structured baseline for continuously improving decision making processes in an organization, which results in higher levels of efficiency and effectiveness (De Felice and Petrillo, 2013). To properly manage a business process improvement program aligned with an organizational strategy, strategy focused organizations should use AHP (Figure 1).

The most critical factor in AHP is to perform *pairwise comparisons* to develop relative weights on criteria hierarchy.

Participants perform multiple sets of comparisons for each level of hierarchy (as shown in Figure 3). For each judgment, participants determine which criterion is more important and by how much. Judgments are used to form ratios in a matrix; The matrix is used to calculate priorities for the judgment set (eigenvector). The Scale for Pairwise Comparison is a comparison scale of 1–9. The consistency index (CI) for all matrices of judgment are calculated according to: CI = $(\lambda_{max} - n)/(n-1)$ where λ_{max} is the maximum eigenvalue and n is matrix dimension.

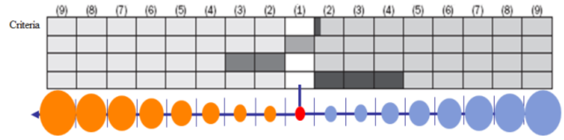

Figure 3: Sample of pairwise comparisons

A sensitivity analysis can be performed to check the sensitivity of the final decisions to minor changes in judgments (Saaty, 2005).

In conclusion, the feature of combining both quantitative and qualitative data and controlling the consistency of expert judgments makes AHP the most applicable to the proposed approach.

4. PROPOSED METHODOLOGICAL APPROACH

The model is based on teamwork and knowledge of multicriteria analysis techniques. It should be noted that multi-criteria analysis is used partly to compare the risk factors, not to compare the risks identified.

Figure 4 shows the general architecture of the proposed methodology. The proposed approach is divided into three phases and each phase is divided into steps. This approach outlines all phases of risk management including: (1) risk identification; (2) risk assessment and (3) actions.

The proposed approach is divided into three phases and each phase is divided into steps:

- *Phase I: Initial State.* The aim of the present phase is to assess the ideal positioning of the company or in other words the *"desidered performance"*. It evaluates the alignment of practices according to the contextual conditions internal and external to the organization. This phase is characterized by the following two steps:
  - *Step 1: Define the problem.* The measure of the complexity of the product-market ratio is determined through the administration of a questionnaire (32 questions).
  - *Step 2: Define Best Practices*. The aim of this step is to identify a set of "best practices" that if used correctly allow the achievement of performance targets. In particular, we investigate 19 best practices. In doing so, we tried to focus on the goals that we had put in terms of *completeness, simplicity and functionality*.

After steps 1 and 2 the answers to the questionnaire are crossed with the best practices and using the method IMS (Independent scoring method) in order to assign all best practices the optimum level (on a scale from 1 to 4), thus reaching the identification of Desideres State.

In particular, a matrix (32 x 19) is built and a correlation coefficient (0 = no correlation , 1= slight correlation, 3 = good correlation, 9= complete correlation) is assigned to each row-column intersection. To calculate for each practice the optimal level L, Equation 1 is used:

$$L_i = \frac{\sum_{h=1}^{32} R_h \cdot d_{ih}}{\sum_{h=1}^{32} d_{ih}} \qquad (1)$$

Where i = 1, ..., 19 h = 1, ..., 32

- *L_i = perfect level for each practice (Desideres State) = R_h values of the answers given in the questionnaire*
- *D_{ih} = correlation coefficients*
- *The value of Li is then normalized in the range 1-4.*

- *Phase II: Current State.* The aim of the present phase is to analyze the current state (the practices actually in use in the company) according to defined best practices. In the phase II a second questionnaire is administered. This phase is characterized by the following step:
  - *Step 3: Gap Analysis.* In this step a gap analysis is conduct between the two profiles (initial state and current state).
- *Phase III: Final State*. The aim of the present phase is to define a degree of importance for all of the good practices identified. This phase is characterized by the following steps:
  - *Step 4: Identify alternative project*. In order to assign weights to the different orientations and then to find the rankings of importance of the strategies Analysis Hierarchy Process approach is used (AHP Matrix).
  - *Step 5: Priority Map.* A two-dimensional mapping of the practices on the Cartesian plane Gap - Significance is defined.

In a similar way as seen in Phase I, is built a second relational matrix whose rows contain the 4 orientations and columns coincide with the 19 best practices. The level of importance of a certain practice is obtained through Equation 2:

$$I_i = \sum_{j=1}^{4} P_j C_{ij} \qquad (2)$$

where

- *P_h = values obtained from the AHP matrix*
- *C_{ih} = coefficient of correlation*
- *i = 1, ..., 19 h = 1, .., 4*

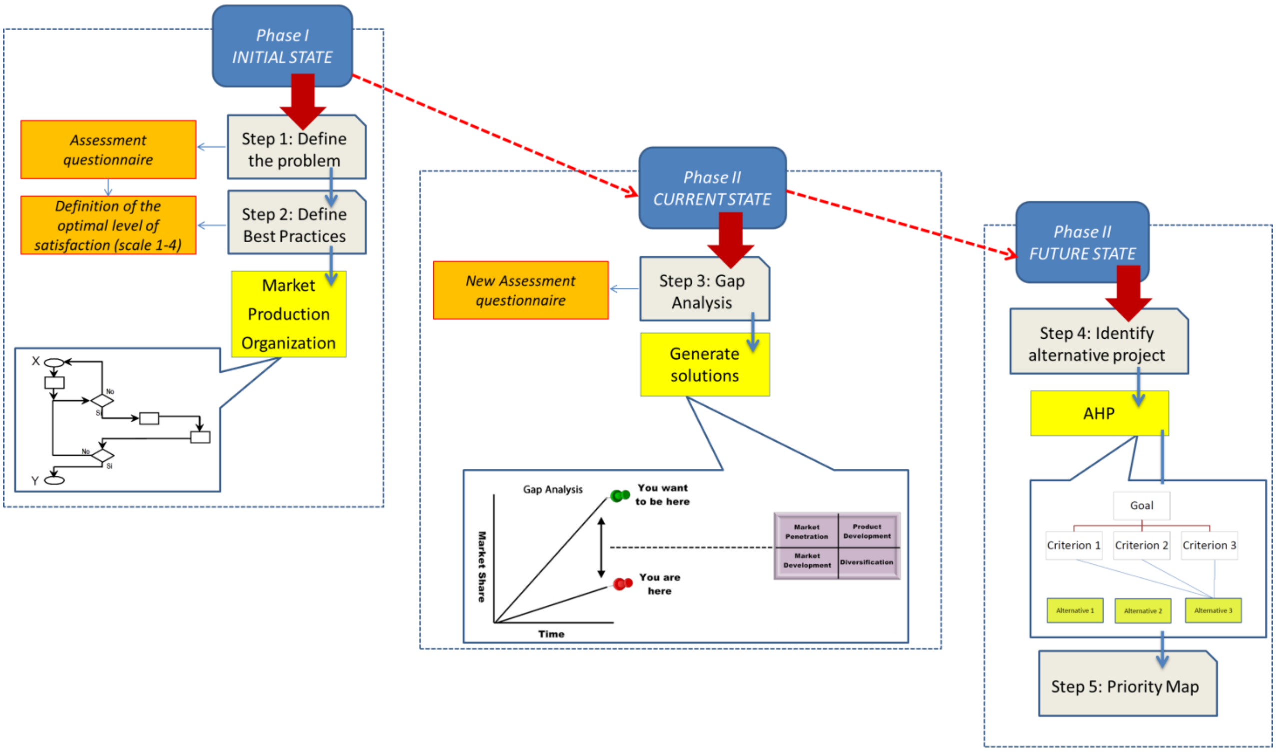

Figure 4: Structure of the methodological approach

5. APPLICATION OF THE PROPOSED APPROACH

In this paragraph the methodological approach is applied to a real case of a multinational company leader in power technologies and automation. In Figure 5 are shown some products.

Figure 5: Products

5.1. Phase I: Initial State

Phase I is the most critical phase because in the present phase it is necessary define the problem and best practices

Step 1: Define the problem. In order to define the "state of the art" a questionnaire is administered to management staff. It consists of 32 statements for which a rating is sought. The degree of agreement or disagreement is expressed in value from 1 to 10 with 1 being the highest and 10 the maximum disagreement agreement. In Table 1 is shown an extract of the questionnaire.

Table 1: Sample of questionnaire

Extract of questionnaire	Average
1. Question 1: The diversity of products is expanding	7,10
2. Question 2: Our products meet customer demands	6,50
3. Question 3: We are competitive	4,20
4. Question 4: We use an appropriate technology	5,15
….	
32. Question 32: Our suppliers are reliable	6,30

Step 2: Define Best Practices. In order to identify best practices 3 dimensions were chosen: market; production and organization.

In Table 2 is shown the Best Practices list.

Table 2: Best Practices List

Best Practices (BP)	
Market	1. New product development strategy 2. Diversity of products 3. Needs of customers 4. Product specifications 5. Marketing new products 6. Eco design
Production	7. Involvement of production personnel 8. Setting goals cost / investment 9. Production strategies 10. Involvement of suppliers 11. Robust Design 12. Production launch new products 13. Integrated product / process
Organization	14. Continuous Improvement 15. Management leadership 16. Project Management 17. R & D 18. New product development team 19. Automated processes

In Table 3 is shown a sample of matrix (32x19)

Table 3: Sample of matrix (32 x 19)

Questions/ Best Practices	#BP 1	#BP 2	#BP 3	#BP 4	…	#BP 19
#Q1	9	0	9	1	…	3
#Q2	3	0		9	…	9
#Q3	1	9	3	9	…	3
#Q4	9	3	1	9	…	1
….	3	9	3	3	…	1
#Q32	1	9	3	9	…	3

For all the best practices a level of satisfaction (scale 1-4) was identified. In Table 4 is shown average level for each practice.

Table 4: Level of satisfaction (L_i)

BP	L_i	BP	L_i
1	3,28	11	2,26
2	3,08	12	2,21
3	2,78	13	2,64
4	2,79	14	3,00
5	2,70	15	3,38
6	2,26	16	2,84
7	2,26	17	2,78
8	3,05	18	3,05
9	2,52	19	3,11
10	2,34		

5.2. Phase II: Current State

Step 3: Gap Analysis. From the comparison between Initial State and Final State differences arise between the two profiles (Table 5).

Table 5: Gap Analysis

BP	L_i	L_{i*}	ΔL
1	3,28	3,16	-0,12
2	3,08	3,02	-0,06
3	2,78	3,13	0,35
4	2,79	3,04	0,25
5	2,70	3,19	0,49
6	2,26	3,17	0,91
7	2,26	3,04	0,78
8	3,05	3,07	0,02
9	2,52	2,93	0,41
10	2,34	3,01	0,67
11	2,26	3,06	0,8
12	2,21	3,12	0,91
13	2,64	2,99	0,35
14	3,00	3,03	0,03
15	3,38	3,10	-0,28
16	2,84	3,05	0,21
17	2,78	3,01	0,23
18	3,05	3,04	-0,01
19	3,11	2,96	-0,15

In Figure 6 is shown the graph on Gap Analysis.

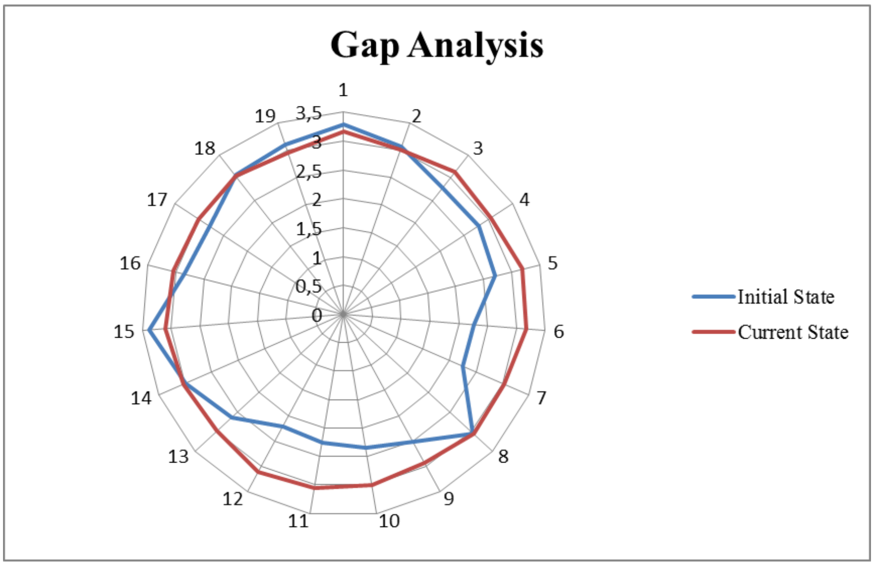

Figure 6: Gap Analysis

5.3. Phase III: Final State

Step 4: Identify alternative project. It is necessary to establish the strategic choices that will guide the development activities by identifying four strategic thrusts: Time to market (C1); Product Cost (C2); Performance/technology (C3) and Quality/reliability (C4). For this purpose AHP Matrix is built.

Table 6: AHP Matrix

AHP Matrix					
	C1	C2	C3	C4	Weight
C1	1	5	5	5	56%
C2	1/5	1	5	5	23%
C3	1/5	1/5	1	1/3	7%
C4	1/5	1/3	1/3	1	14%
tot	1,60	6,53	14,0	9,33	100%

Table 1: Single Line Table Caption

BP	I	BP	I
1	7,57	11	3,00
2	2,00	12	6,42
3	3,42	13	6,42
4	2,25	14	1,56
5	5,50	15	8,47
6	1,86	16	5,51
7	2,87	17	2,62
8	3,29	18	3,75
9	4,05	19	3,00
10	5,18		

Step 5: Priority Map. In Figure 7 Priority Map is built.

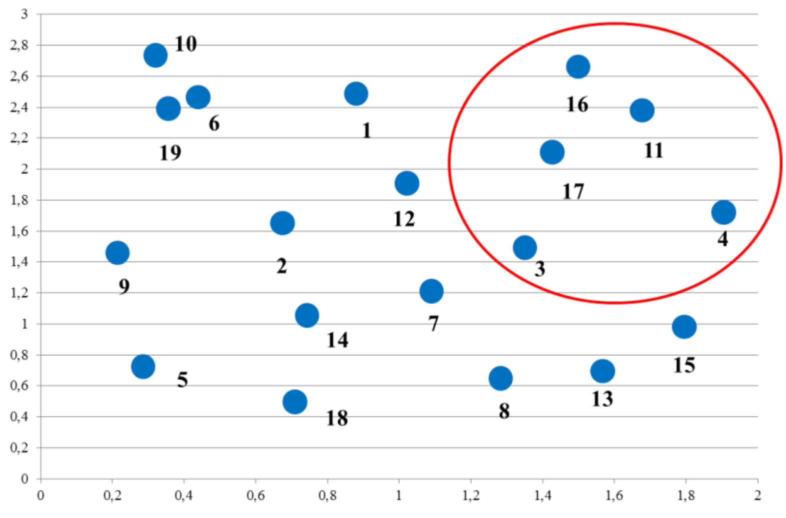
Figure 7: Priority Map

Our study shows that specific risks are being perceived in several projects. These risks might be inspected thoroughly to find ways for structural improvement on them. The framework can also be beneficial for other companies. R&D management can take the framework and customize it for use in their projects. For this, they need to take the model and delete from it what is not relevant and to add what is missing. In this way, the framework can be given a first customisation round. In subsequent use at starts-ups or during different development phases, the model could be refined and customized further.

6. CONCLUSION

We developed an integrated model that was applied to manage the performance of product development in order to measure their achievement and activate pathways for improvement.

The study results indicate the practical feasibility of our integrated model, which includes an innovative design tool and an MCDM framework for innovative and sustainable product development. Of course the proposed model cannot claim to include every risk issue that may appear during a specific development project. The challenge is to have and use an approach that stimulates people involved to identify risks, while there is time to take action to manage them. For this, some kind of formal risk assessment needs to take place during a long period time. Making a judgment on perceived risks, involves the integration of a large amount of information. Therefore, we conclude that it is preferable to add a structured and systematic component to the process of risk identification. The company investigated can use the framework as one of their tools to make people aware at the start and during the development of new products of the risks that are associated with their projects. Further use of the framework for the research company might include efforts to improve their practices.

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