The integration of TRIZ and Risk management to increase the ratio of success of innovation Projects

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Abstract.
This paper explores the interaction of project risk management and TRIZ in innovation projects. We started with this paradox: when we generate brand new solutions to existing problems, almost no information is available; however, such information is necessary to evaluate the innovation project success probability. The potential and the cost of a conceptual idea are much more difficult to evaluate than for detailed solutions. This difficulty can let solutions “in a drawer”. In this article we tackle the difficulty to reliably evaluate probability of success of innovation projects, using an adapted risk management strategy.

Keywords:
TRIZ, innovation portfolio management, Relevent™ diagram, risk management.

1. INTRODUCTION

This paper is linked to the paper presented at TRIZ Future Conference 2007 by G. Bersano & V. Bregonzio [1] and consists in a deeper exploration of the interaction of project management key element as the risk management and TRIZ in the development of new products and systems. Normally in companies when brand new solutions are generated to existing problems, few information relating to the innovative solution is available; however, such information is necessary to evaluate the innovation project success probability (in term of feasibility, capacity to solve the problem, risks etc). Furthermore, the potential and the cost of a conceptual idea are much more difficult to evaluate than the ones of more detailed solutions. In this paper we suggest the adoption of an adapted risk management strategy to be integrated from the beginning of an R&D activity.

2. CRITICAL INNOVATION

2.1 Recent surveys on innovation and its goals

Let us first define what innovation is. We adopt the following definition, proposed by the European Commission: “the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply and distribution; the introduction of changes in management, work organization, and the working conditions and skills of the workforce”, [2]. A recent survey in France, done by the French Ministry of Industry and Economy organization (SESSI) has checked on 24000 enterprises the perception of innovation on products, process, organization, etc, [4]. The results show a positive impact for 86% of the companies:

- for 74,4% of the companies, innovating had a positive impact on the products;
- for 50,3% innovating had a positive impact on processes;
- 34,2% of the companies observed other positive impacts.

The same study shows the main reasons that induced companies to launch innovation projects: improve product quality, conquer new markets and widen the product portfolio are the first three reasons. These innovation objectives will later give us the keys to precisely evaluate the success probability of an innovation project. However, although more than 80% of companies acknowledge the positive impact of innovation, the same statistical review shows that companies do not always turn ideas into success: 23,4% of the companies stopped their innovation project (among which 18,7 percent stopped the project during design, and 14% after the project launch) and more than 30% of the companies suffered serious delays in their innovation project. Hence, although innovation is needed to improve product quality, conquer new markets or widen the product portfolio, almost one fourth of the innovation project is simply stopped. What about the other 75% of projects that continued? The research work of Pr. C. M. Christiansen [5] established that no more than 10% of products launched on the market are real successes. What are the reasons why a forth of innovation projects are stopped and only one tenth of the others are really successful?

2.2 Situation analysis

In this paragraph, we present what we will name Innovation Project Failure Source (IPFS): an event (inside or outside the company) that can prevent the innovation project to be successful. An innovation project can be stopped because there are too many potential IPFS (strong competition, limited market share, etc.). We identified IPFS based on a basic literature review. Table 1 summarizes five sources, [6], [7], [8], [9] and [4]. It is very interesting to see that the uncertainty about technology is the less often mentioned issue, this highlights the somehow lack of focus of decision makers about technology and its complexity. Is technology a commodity? According to these responses the answer is generally yes… In order to complement these results, we investigated other information sources. As a summary of Table 1, we propose 6 generic

IFPS: **#1 No innovation friendly culture.** It integrates the climate issue (risks are avoided, uncertainty is not tolerated, no openness, rigid domain, conservative industry, difficulty to tolerate mistakes, no creativity opportunity, no possibility to explore uncommon ideas, etc). It also takes into account the capability of the company to introduce the needed change within its own structure and way of working. **#2 Poor management of projects.** This relates to project management techniques first: no clear responsibilities in project team, poor project manager, no fully dedicated project manager, too much loop back in the project. It also takes into account the way each project phase is executed. Absence of team work, which could more efficiently lead to inventive solutions, is part of this IPFS. This IPFS also integrates the fact that the project does not have all the necessary resources (fund, human resources, etc). **#3 Poor competitiveness.** The product is not better than the competition, or it does not have better properties (better functions, cheaper, more reliable, etc.). Or maybe the competition will launch a brand new product. This IPFS also integrates the fact that the market is dominated by very stable and powerful companies. Maybe no customer needs the product we have built. The need does not exist yet (market pull), or cannot be created (technology push). **#4 Low hierarchy commitment.** Stakeholders and management are not enough committed (not involved early, no common understanding). There is no constant interaction with management and stakeholders. **#5 Lack of knowledge about the market & the technology**: very often the company is not capable to perform a proper market analysis and forecasting, therefore hesitates before launching new products; moreover, ideas are often found outside company core competencies or strategy. **#6 Lack of funding and partners:** all activities related to innovation needs resources (both human and financial) and this is often critical for small companies.

In Figure 1, we use the RelEvent diagram of the General Theory of Innovation [6] to show which step of the innovation process can be blocked by the IPFS we identified. This analysis showed us that many uncontrollable events can occur all along the innovation project and prevent it to be completely successful. In the same way we can identify that some characteristics of the company influence greatly the probability of success of an innovation initiative, and these have to be considered more as controllable choices. Such a list can be used as a checklist in order to increase the chance of success: each IPFS if present should be controlled by necessary corrective or preventive actions. This can dramatically increase the innovation project success probability. Starting from this graphical analysis, we can try to block the flow of negative events, introducing these specific counteractions:

- Application of market intelligence;
- Portfolio management;
- Application of state of the art project management;
- Application of innovation management techniques and systematic innovation;
- Partnership and collaborations.

In the following paragraphs, we will focus on portfolio management, and present some considerations and techniques that can be used by a manager to select innovation projects.

3 TECHNIQUES TO MANAGE INNOVATION PORTFOLIO

3.1 Focus on technical aspects using Laws of Technical System Evolution

In TRIZ body of knowledge, the Laws of technical system evolutions are frequently used as a tool to generate ideas [11]. Other authors identified other trends to be added in order to be used to select ideas, see for example the work of Darrell Mann [12]. In fact, TRIZ offers a new point of view to the manager willing to decide whether or not the project should be maintained. TRIZ states that the new product version should only be launched if its modifications from the preceding versions are consistent with the laws of technical system evolution. For example, there is no need to think about transiting to the super system if the system still has poor energy conductivity.

3.2 Focus on market/product strategies according to M. Porter

M. Porter [13], analyzed the possible strategies for a company in a competitive scenario. The three possible alternative strategies are the following: domination (1) by costs (2) by differentiation or (3) by concentration on a limited market segment. According to J.M. Higgins [3] the first two strategies can be deployed by innovation. Figure **2** shows the bi-dimensional result of their analysis for the first of the two strategies. The horizontal axis is the relative cost of the product, compared to the competition, and the vertical axis is the relative differentiation. The author claims that the worst situation is when the relative cost of a product is high and the relative differentiation is low. He also claims that the best situation is when the relative cost is very law and the relative differentiation is high. However, such selection criterion can be pretty difficult to assess in early project phases.

3.3 Focus on Christiansen theory about innovation patterns

A few years ago, Pr. Clayton M. Christiansen from Harvard University, developed a theory of companies evolution and survival based on some innovation pattern. Christiansen links the nature of the innovation project and the company's structure (see Figure 3). According to this diagram, if we are looking for sustaining and standard products, i.e. we are in zone B, functional organization and main commercial structure are adequate; but if we want to provide new products or services that are misaligned with company standard processes and values, then the company organization could be no more adapted and strategies as creation of start-up or dedicated divisions become mandatory in order to succeed.

3.4 Focus on system aspects of the new product using Coefficient of Freedom (GTI)

Greg Yezersky, in his General Theory of Innovation, enhanced the TRIZ Ideality concept and named it Coefficient of Freedom. This coefficient is in the line of the concept of interdependency with the environment, as described by economists J. Pfeffer & G.R. Salancik in the Resource Dependence Theory (RDT), [6]. The Coefficient of Freedom is defined as the ratio between functionalities of the system and system connections with its environment. Yezersky states that technical systems follow the trend of increasing their Coefficient of Freedom. Therefore, this technique can be used to select innovation project: if the Coefficient of Freedom of the new product is not higher than the ones of the preceding version, it is not worth investing time and money in this project. This criterion can also be used to compare company's product with the competition ones. GTI states that the product of higher Coefficient of Freedom will win the highest market share.

3.5 Conclusion

Although we were not trying to present an exhaustive list of portfolio management techniques, it already appears that these techniques focus only on a subset of the identified IFPS. Rather than developing new techniques to assess if the possible IPFS will or won't lead to project failure, we simply introduce in the following paragraph the Risk Management technique, as proposed by the Project Management Institute (PMI®).

4 ADAPTING RISK MANAGEMENT TECHNIQUE TO ASSESS INNOVATION PROJECT SUCCESS PROBABILITY

4.1 PMI risk management

The Project Management Institute (PMI®) is an international organization of project managers. One of the objectives of this institution is to collect and disseminate knowledge and best practices of project management, [15]. Amongst the nine knowledge areas that constitute the PM body of knowledge, we will focus on project risk management.

The objectives of a risk management technique are (1) to evaluate whether or not the project can reach a scope (time, cost and quality of output) and (2) to plan necessary actions in order to reach the scope. Generally speaking, risk management aims at increasing the probability and impact of positive event and decrease the probability and impact of negative impacts. As proposed by PMI, the risk management has six major steps. **Risk management planning.** Here, the objective is to decide how to approach, plan and execute the risk management activities. The kinds of decision that must be taken at that stage are: who will manage the risks, who are the members of the team, how much time can be dedicated to this, which precision level should be adopted, what risk threshold is the most suitable, etc. **Risk identification.** This activity aims at determining what event might affect the project and documenting their characteristics. The events can be searched in the four following categories: technical (requirements, technology, reliability, etc.); external (subcontractors, regulatory, market, etc.); organizational (project dependencies, resources, funding, etc.) and project management (planning, controlling, etc.). **Qualitative analysis.** This third activity is to prioritize the risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact on project objectives. The occurrence probability for each event is qualitatively evaluated as well as the impact of the event (for example with a 5 levels scale). The risk can then be estimated by simply multiplying the probability and the impact. If the risk is more than a threshold value, then corrective actions are planned. **Quantitative analysis.** This consists of a numerical analysis of the consequences on overall project objectives of the most critical events identified in the qualitative analysis. One calculates the possible outcomes for the project and their probabilities. For this quantitative analysis, two techniques are classically used: probabilistic (decision) tree and statistic analysis. The second technique enhances the analysis by considering statistical aspects. Rather than assigning a fixed value to the impact, one use continuous distributions curves (Beta distribution, triangular distribution, Gauss law, etc.). This principle is also applied for the occurrence probability. Therefore, the project success distribution is calculated by mathematical operations on impact and probability distribution. **Risk response planning.** This phase of risk management consists of developing options and actions to both enhance opportunities and reduce threats to project objectives. Four strategies deal with the negative events: (1) Avoid. This means to change the project so that the event does not exist anymore; (2) Transfer. Transfer the risk on someone else. Insurances are a typical ways of transferring the risk; (3) Mitigate. Mitigate the probability and/or impact to an acceptable threshold; (4) Accept-it. **Risk monitoring and control.** This final stage is planned to track identified risks, monitor residual risks, identify new risks, execute risk response plans and evaluate their effectiveness throughout the project life cycle.

4.2 Example

We show in Table 2 a typical result of a qualitative risk analysis. The first column of the table lists the name of the IPFS. The second shows the IPFS occurrence probability. This number is 0 if it is very unlikely that the event will happen and 1 if one can be sure that the event will occur. The third column provides a qualitative evaluation of the impact on the project. One put 0 if the event would have no consequence and 1 if it would directly lead the project to complete failure. The fourth column is the risk assessment: the occurrence multiplied by the impact. Therefore, if the risk is 0, the event is not risky and if is 1, it means the event is dramatic. Column 5 shows the risk response planning.

In order to enhance the risk quantification, we assess each criterion with a basic Gauss law, with standard deviations and expected values mentioned in Table 3. A high standard deviation represents a large range of possible values. Mathematical calculations on these four curves allow us the identification of the project success distribution shown Figure 4. The most probable project success is about 0,25. One can also see that the probability the project meets more than 20% of its objective is about 0,75.

4.3 Applying risk management to Innovation Project Evaluation

In the last paragraph, we have presented the Risk Management, as proposed by the Project Management Institute. Let us know investigate how this technique could be used in order to help the manager in deciding whether or not an innovation project should be pursued (what is the most probable result, and the most probable required investment). Based on both the literature review and Risk management technique, we built Table 4 which is a template for qualitative risk management in Innovation project.

Another use of risk management techniques in the scope of innovation project is the application of the decision tree (quantitative analysis of risk techniques). In Figure **5**, we show a possible implementation of the decision tree to innovation projects. Using simple calculation it is possible to give a quick feedback of different scenarios, in order to support company decision makers.

Concerning the use of statistical law for probability and impact in the quantitative phase, we must notice that in any innovation context some risks can be very difficult to assess. Standard deviations for occurrence probability and impact are high; therefore, the project success ranges over a wide windows, which makes the risk management technique completely useless. How can we decide whether or not the project can be successful or not? This is also applicable for evaluating the resources needed for the project: when the standard deviations of influencing events are too high, the evaluation of needed resources is not precise enough. Finally, the key problem of innovation project evaluation is the difficulty to provide a precise yet reliable assessment for events influencing the project (success, needed resources, etc.). In the next paragraph, we apply TRIZ solving tools to imagine new Risk Management techniques, more suitable for innovation projects.

4.4 How to improve the quantitative risk analysis with TRIZ

The aim of Risk Management is to provide an evaluation of a project needed resources and possible outcome, taking into account an extended list of influencing factors (some of them depend on the company itself and some others cannot be controlled). Based on this evaluation, corrective actions can be performed, in order to increase the probable project success ratio (or success probability) or reduce the needed resources. One can say that the risk Management technique should reduce the gap between “assessed project ideality” and “achieved project ideality”. Within a standard design scope, the Risk Management technique proposed by PMI can achieve this function. However, within an innovative scope, this gap cannot really be reduced. Let us try to formulate the contradictions to be solved.

The first contradiction formulation we propose is the following: it is impossible to precisely evaluate an innovation project (as it is impossible to precisely assess impacts and probabilities of each project ideality influencing events) however, evaluating an innovation project is crucial (because decision must be the good one: do not continue with a project dedicated to failure and do not stop a probably very successful other one). We could also propose this other contradiction: if the values of probabilities and impact of influencing events are simply guessed, then the evaluation technique is very simple and rapid, but the evaluation is not enough precise (the gap between what was expected and what really happened can be huge); on the other side if we spend time and money for a precise assessment, then the evaluation might be very close to reality, but such an evaluation can be very complex and time and money consuming. Ideally, we need a technique to evaluate an innovation project which is both reliable (ie: the prior evaluation is close to what will really happen) and use few resources (time, money, complexity, interactions, etc.).

We used TRIZ databases to imagine some solutions to these contradictions. We only provide here the five ideas we think the most interesting:

- **Separation in system level**: install as much routine as possible within the innovation project (for example: predictable cost, unpredictable technical domain). Here are possible implementations: always work with external technical expert for the development phase; rather than performing the innovation project, the company could only be the coordinator of external subcontracting companies
- **Excessive action**: the project can have many possible positive results. For example: everything could be organized so that even if the project is a failure, its by-products will be very useful for the company (knowledge about innovation strategy, technical expertise, knowledge about competitor behavior, maybe the useless machineries can be rented rather than sold, etc.).
- **Before cushioning**: the company should be accustomed to uncertainties about project needed resources and potential result. One could for example imagine computer based simulations tools; another possibility could be to use little yet highly uncertain projects as laboratories to test some uncertainty management techniques or as “pedagogical exercices”. Another interpretation of this inventive principle can be in the form of joint venture with competitors of specific collaboration contracts, etc.
- **Other way around**: rather than evaluating a project proposal, propose project on the basis of target ideality (the target budget is one of the input of project building).
- **Local quality**: rather than to have a precise risk assessment, the company could focus its attention on corrective actions and being extremely reactive to its changing environment.

These proposals should be further defined in term of project procedures, and then tested.

5 CONCLUSIONS

We started this study with the feeling that innovation difficulties have roots far away from technical problems, and this has been confirmed by the analysis reported in section 2. We used TRIZ based problem solving tools to identify that some project management aspects (and more particularly risk management) are still weak in an innovation context. We formulated the contradictions relevant to Risk management and applied TRIZ solving tool (mainly inventive principles) to improve risk management techniques. Only if we will be capable to solve customers' main problems, that are mainly non technical, we will succeed in improving the general rate of success of innovation projects.

6 REFERENCES

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TABLES AND FIGURES

#	[6]	[7]	[8]	[9] (top ten, out of 16)	[4]
1	Culture does not embrace innovation and risk taking;	No clearly visible added value	Ignorance about what an innovation project should be	No funding for innovation	Lack of financial resources within the company, the group or the network
2	Innovation is not aligned with company's mission and goals;	The product is not better	Lacks of skills for some key tasks	Staff not enough competent	The innovation is too costly
3	There is no customer for the product;	Weak project management	Wrong use of existing innovation procedures	No collaborative environment	Lack of need
4	No mistake are tolerated in the company	No success celebration and rewarding	Too confident: we already know the answers, so why do all this extra work?	No key individual / leader champion	Lack of qualified human resources
5	No possibility to make exploratory thinking and idea generation.	No management commitment	Lack of discipline and leadership	Infrastructure does not support innovation	Market dominated by stabilised company
6	No teamwork	Project leader not fully dedicated	Big hurry, and no time to do things right	No multidisciplinary approach	Uncertainty about demand

7	No cross-functional collaboration and communication	No ambition	Too many projects and not enough resources	Difficulty to change technological landscape	Preceding innovations
8		No experts in the field		Lack of strategic planning	Lack of financial resources outise the company, the group or the network
9		All stakeholders are not involved		No competitive requirement	Difficulty to find partners
10		Closed minded culture		Industrial sector not innovation friendly	Lack of information about markets
11					Lack of information about technology

Table 1. Summary of IPFS proposed in literature

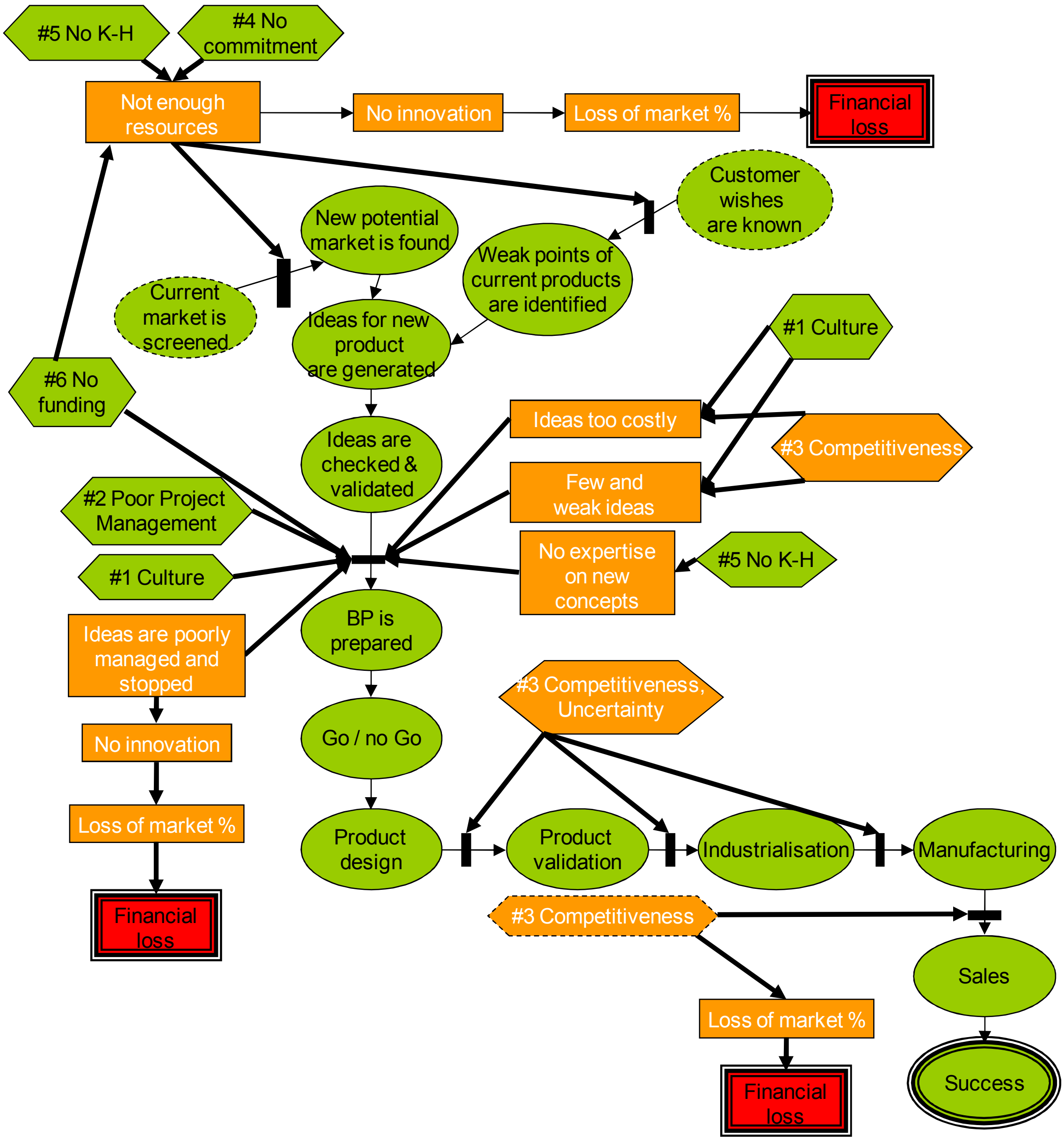

Figure 1. RelEvent diagram for an innovation project

Figure 1 should be read the following way: Dashed lines describe input event; green components are useful event, linked to the function of the system; orange components are negative events. They prevent the system to correctly perform its function; ellipses are intermediate positive events and rectangles are intermediate negative events.

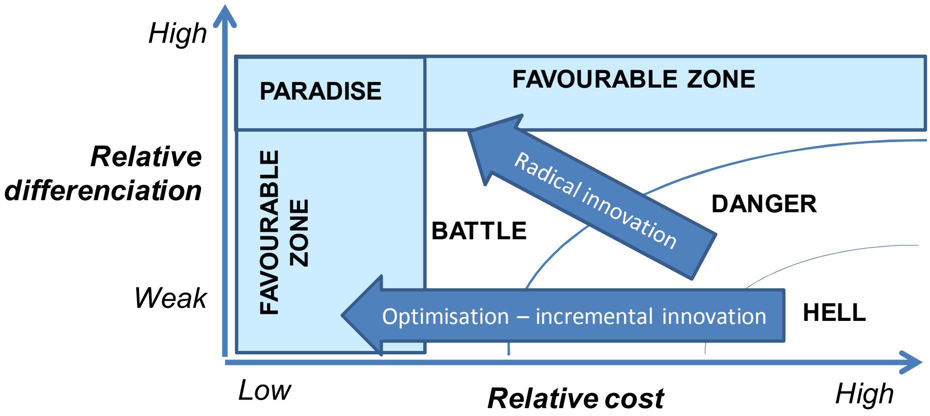

Figure **2**. Two axis for product selection

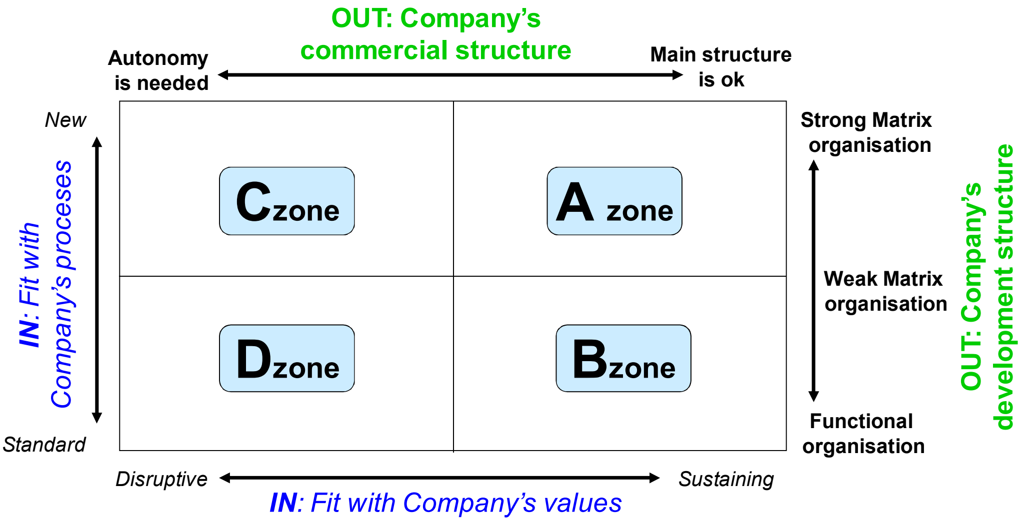

Figure 3. Christiansen company's fit with innovation patterns

Event	Occurrence probability	Impact	Risk (Threshold: 0,3)	Corrective actions
Poor competitiveness	0,6	0,6	0,6x0,6 = **0,36**	(1) Market intelligence (2) Joint ventures (3) Intensive marketing and advertising
Lack of K-H	0,8	0,5	0,8x0,5 = **0,4**	(1) Hire expert of the technical field (2) Special training

Table 2. Qualitative analysis of two IPFS

	Lack of know how		**Poor competitiveness**	
	Occurrence probability	**Impact**	**Occurrence probability**	**Impact**
Standard deviation	0,8	0,5	0,6	0,6
Expected value	0,7	1	0,5	1

Table 3. Standard deviation and expected value

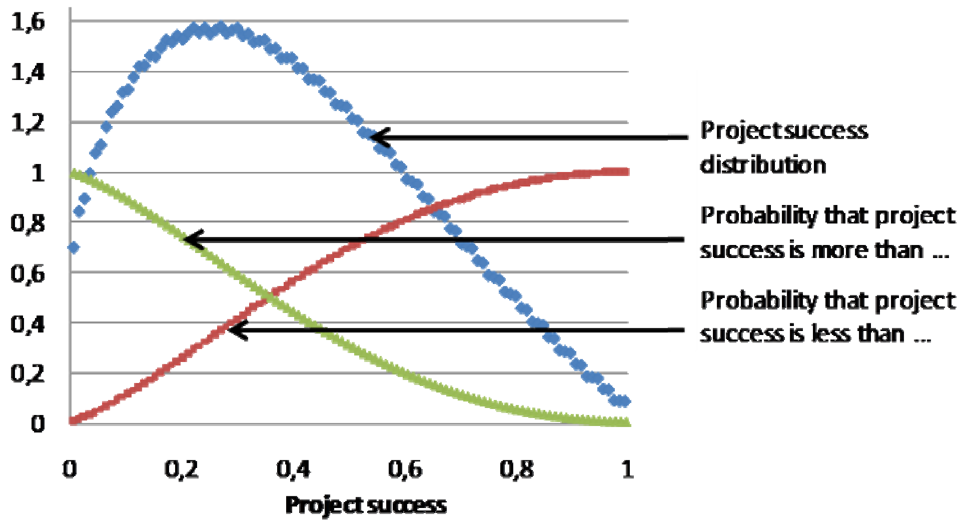

Figure 4. Distribution of project success values

Domain	#	Event Name	Probability	Impact	Risk	Corrective actions
Organization						
	I1	Culture does not embrace innovation				
	I2	No teamwork				
	I3	No commitment from management				
	I4	Not enough funding				
Product	…	…				
	P1	Product function #1				
	P2	Product function #2				
Project						
Design	PJ1	No expert				
	…	…				
Manufacturing	PJ2	No known manufacturing technique				
	PJ3	Unpredicted manufacturing defect				
Sales	PJ4	No clear added value				

Table 4. Generic qualitative IPFS assessment

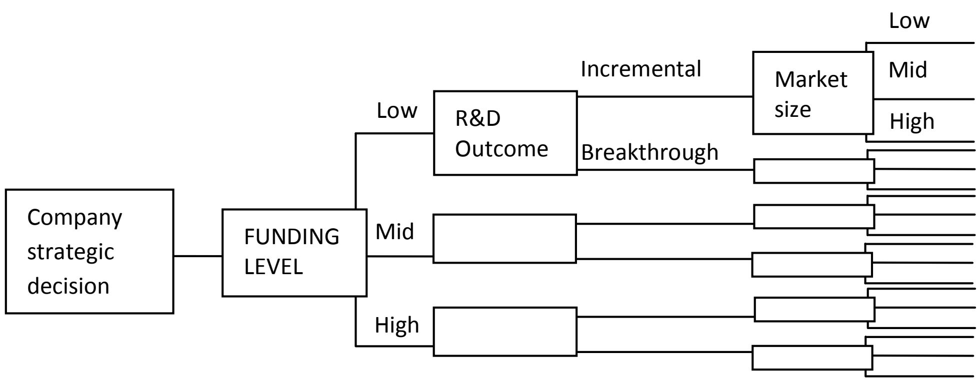

Figure **5**. Decision tree for innovation project