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TOWARDS DEVELOPING A DECISION-MAKING TOOL FOR TECHNOLOGY AND KNOWLEDGE PRIORITIES

Rumo ao desenvolvimento de uma ferramenta de decisão para prioridades de tecnologia e conhecimento

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Abstract: The main focus of this paper is to propose a method for prioritizing knowledge and technology factor of firms towards sustainable competitive advantage. The data has been gathered and analyzed from two high tech start-ups in which technology and knowledge play major role in company‘s success. The analytical hierarchy model (AHP) is used to determine competitive priorities of the firms. Then knowledge and technology part of sense and respond questionnaire is used to calculate the variability coefficient i.e. the uncertainty caused by technology and knowledge factor. The proposed model is tested in terms of two start-ups. Based on the initial calculation of uncertainties, some improvement plan is proposed, and the method is applied again to see if the uncertainty of knowledge and technology decreases. In both cases, the proposed model helped to have a clear and precise improvement plan and led in reduction of uncertainty.

Key words: Sense and respond method; Sustainable competitive advantage (Sca); Knowledge and technology (Kt); Uncertainties; Analytical hierarchy process (AHP)

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RUMO AO DESENVOLVIMENTO DE UMA FERRAMENTA DE DECISÃO PARA PRIORIDADES DE TECNOLOGIA E CONHECIMENTO

Towards developing a decision-making tool for technology and knowledge priorities

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Resumo: O foco principal deste artigo é propor um método para priorizar o conhecimento e o fator tecnológico das empresas, visando uma vantagem competitiva sustentável. Os dados foram coletados e analisados a partir de duas empresas iniciantes de alta tecnologia, nas quais a tecnologia e o conhecimento desempenham papel importante no sucesso da empresa. O modelo de hierarquia analítica (AHP) é usado para determinar as prioridades competitivas das empresas. Em seguida, o conhecimento e a tecnologia, parte do questionário de sentido e resposta, são usados para calcular o coeficiente de variabilidade, ou seja, a incerteza causada pela tecnologia e pelo fator de conhecimento. O modelo proposto é testado em termos de duas start-ups. Com base no cálculo inicial das incertezas, é proposto algum plano de melhoria e o método é aplicado novamente para verificar se a incerteza do conhecimento e da tecnologia diminui. Nos dois casos, o modelo proposto ajudou a ter um plano de melhoria claro e preciso e levou à redução da incerteza.

Palavras-Chave: Método de detecção e resposta; Vantagem competitiva sustentável (Sca); Conhecimento e tecnologia (Kt); Incertezas; Processo de hierarquia analítica (AHP)

ACEITO EM: 08/09/2019

1 Introduction

The world is changing rapidly so is the business environment. This turbulent environment in business world affects the dynamic nature of competitive advantage among firm and makes the competition more intensified. According to Si, Takala and Liu (2010) ―The future competitiveness of manufacturing operations under dynamic and complex business situations relies on forward-thinking strategies‖. One of the key drivers of competition is technology change. Any technological modification which could pioneer a firm in an industry is considered valuable. Although the technology factor plays an important role in obtaining profit for a company, it is not important for its own sake. It is important if can help companies to reduce cost or make differentiation or speed up delivery (porter,1986).

Technology changes and development could create new opportunities and as well as threats to companies (Takala&Zuchetti, 2016). It also important because it can affect industry structure and create new rules of competition. Understanding the effects of technological changes on the structure of an industry has even more importance in the era of digitalization and industry 4.0 (Oettmeier& Hofmann, 2017). It is perceived that competing in ―high technology‖ industry is considered as key to gain profit (Porter, 1986). But it also demands lots of company resource, since it forced company to adapt to the technical requirements of the market continually (Takala&Zuchetti, 2016). So, it is very much important to look at technological capability of firms with resource based view approach and make decision about technology investment regarding companies limited resources.

This paper tries to evaluate technology and knowledge factor and connects it to companies‘ business strategy. Additionally, it aims to show how technology and knowledge decision reflect uncertainties. Managing uncertainties in business strategy is very important since it is replacing traditional risk management (Takala and Uusitalo). Therefore, this article is a step towards modelling knowledge and technology priorities considering business strategy.

2 Theory Background

2.1 Business strategy

Quinn 1980 defines strategy ―the pattern or plan that integrates an organization‘s major goals, policies and action sequences into a cohesive whole‖. Nowadays firms need to apply strategies that can grantee their sustainable competitive advantages over others rather than only gaining short term benefit. The notion ―sustainable competitive advantages‖ (SCA) was defined by porter in 1985. He proposed a positioning theory based on generic strategy. His positioning theory classified business strategy in three main categories: overall cost leader ship, differentiation and segmentation. In cost leadership category, companies seek to deliver product and services at lowest price by different means like optimizing process and standardize their products and services. In differentiation category companies seeks to deliver superior products and services by offering high quality and/or customized products and finally in segmentation group, companies focus on fulfilling unique needs of selected segment of customer based on geography or income level (Porter 1980). This categorization was not comprehensive enough because it did not consider firm‘s resources and internal capabilities. Based on Wernerfelt (Wernerfelt, 1984), in finding optimal market for a firm, its products and its resources should be taken to account at the same time because resource and product are two sides of a coin for firms. Later on, Barney includes the role of resources in company business strategy as they can bring competitive advantages to firm. Because firms‘ resources are rare, have no direct substitutes, and help companies to achieve opportunities or avoid threats. Regarding companies‘ resources, competitive strategy is defined as creating value chain that cannot be implemented or duplicated by others easily (Barney, 1991).

Another classification of business strategy could be based on Miles and snow topology. In this model four business strategy groups are defined: prospector, analyzer, defender and reactor. prospector is those firm which try to lead their industry, their main focus is to deliver high quality products. Analyzer tries to focus on quality and cost simultaneously and remain steady in their market. Defenders try to minimize cost and focus on a mature product or market operation, they concentrate on process improvement and prefer not to take risks. And finally, reactor happens in absence of any clear strategy (Daft, 2009)

2.2 Sense and Respond model (S&R)

This model was introduced by Ranta and Takala in 2007 and assists frim in estimation about what would happen in future. This method is replaced traditional way of planning production and is more based on

anticipation customers‘ need on real time. This method helps firms to collect data regarding their experience and expectation and provides a way for firm about how they see themselves compare others in terms of different attributes. Additionally, it helps firms to see the development of a certain attribute in a specific time frame (Strauss and Neuhauss 1997; Bradley and Nolan 1998; Ranta and Takala 2007).

The sample of questionnaire is presented in the following table:

Table 1 Format of the Questionnaire

Performance attribute	Scale: 1=low, 10=high		Compared with competitors			Direction of development		
	Expectation (1-1)	(1-10)	Experience	worse	same better	same	better	worse
Performance 1								
Performance 2								

, the following attribute has been used for performance measurement in sense and respond questionnaire:

Table 2 mple of Performance Measurement Which Has Been Applied in This Study

	ATTRIBUTES	
	Knowledge & Technology Management	
1	Training and development of the company's personnel	← Flexibility
2	Innovativeness and performance of research and development	← Cost
3	Communication between different departments and hierarchy levels	← Time
4	Adaptation to knowledge and technology	← Flexibility
5	Knowledge and technology diffusion	← Cost
6	Design and planning of the processes and products	← Time
	Processes & Work flows	
7	Short and prompt lead-times in order-fulfillment process	← Flexibility
8	Reduction of unprofitable time in processes	← Cost
9	On-time deliveries to customer	← Quality
10	Control and optimization of all types of inventories	← Quality
11	Adaptiveness of changes in demands and in order backlog	← Flexibility
	Organizational systems	
12	Leadership and management systems of the company	← Cost

Continual Table 2

	ATTRIBUTES	
13	Quality control of products, processes and operations	← Quality
14	Well defined responsibilities and tasks for each operation	← Flexibility
15	Utilizing different types of organizing systems	← Flexibility
16	Code of conduct and security of data and information	← Cost
	Information systems	
17	Information systems support the business processes	← Time
18	Visibility of information in information systems	← Time
19	Availability of information in information systems	← Time
20	Quality & reliability of information in information systems	← Quality
21	Usability and functionality of information systems	← Quality

2.3 RAL model

To integrate sense and respond method to Miles and snow typology, RAL model is used. RAL is abbreviated from responsiveness, agility and leanness. According to Takala (2012), a firm can be optimized in terms of responsiveness, agility and leanness by prioritizing quality, cost, time and flexibility.

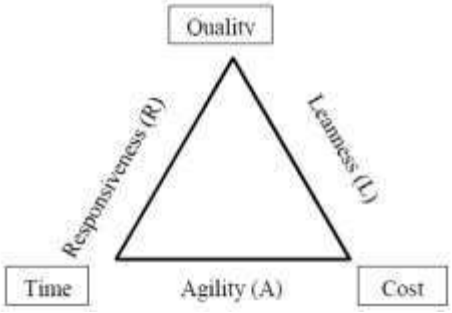

Figure 1 RAL Model

2.4 Technology and knowledge rankings

Knowledge and technology requirement is added to sense and respond questionnaire to gather information about companies‘ knowledge and technology priorities. Since the company‘s resources is limited, so it is very important to find the technology focus which is align with company business strategy and can grantee firms competitive advantage and profitability. Based on Marone (Marone, 1989), technology can provide opportunities and bring competitiveness to firms. Additionally, technology strategy plays an important role in the success of technology-based startups and improves their competitive advantage (Campos et.al, 2009). Therefore, companies should integrate it to their business strategy.

To gain sustainable competitive advantage and create core competences, knowledge and intellectual capital also plays significant role. According to Libut (Libut, 2001), achieving sustainable competitive advantages is mainly based on knowledge meaning that in order to create value chain, knowing how to do thing is as important as having access to special resources. To create value chain, knowledge should be shared effectively within firm while be protected from liking outside. So, to gain competitive advantage knowledge, skills and intellectual property should be easily shared inside the firm but difficult to be copied by competitors. This kind of knowledge which is ―difficult to express, formalize or share‖, called tactic knowledge. Tactic knowledge is very much related to firms‘ experience, organization structure and routines (Libut, 2001). The role of technology in organization and getting competitive advantage is even more important in terms of ―technology entrepreneurship‖ and high tech business and so many studies has been conducted to investigate it in terms of resource based view, dynamic capabilities and core competence (Bailetti, 2012).

To evaluate knowledge and technology impact on firm business strategy, respondents have to estimate each attribute of sense and respond questionnaire in terms of basic, core and spearhead technology. In other word respondents should detect the share of these three technologies in term of each attribute while the sum of all shares is 100%. Here, basic technology means the kind of technology which is used commonly and can be purchased or outsourced. Core technology refers to the technology that is bringing competitive advantage to company currently and spearhead technology refers to future technologies. These three different technologies differ each other in terms of required resource and knowledge. This difference influences a lot in firm‘s strategy implementation and in particular to the success of high tech-based business (Takala et al, 2013).

Table 3 Technology and Knowledge Share for Different Attributes

	Basic	Core	spearhead
Performance 1			
Performance 2			
Performance 3			
Performance 4			

3 Method

In this study, analytical hierarchy process (AHP) model and knowledge and technology part of sense and respond questionnaire is used. AHP method is used to weight the component of RAL method: quality, cost, time and flexibility. Analytic Hierarchy Process (AHP) method is based on pairwise comparison between criteria and was introduced by Saaty in 1980. This method is ―a multi-attribute decision instrument that allows considering quantitative and qualitative measures and making tradeoffs‖. In order to calculate the partial uncertainty regarding to each type of technology, this paper suggests variability coefficient. The formula is as follow:

$$\text{Coef. Var}_{\text{Basic}} = \frac{\text{Standard Deviation}_{\text{Basic}}}{\text{Average}_{\text{Basic}}} \quad (1)$$

$$\text{Coef. Var}_{\text{Core}} = \frac{\text{Standard Deviation}_{\text{Core}}}{\text{Average}_{\text{Core}}} \quad (2)$$

$$\text{Coef. Var}_{\text{Spear Head}} = \frac{\text{Standard Deviation}_{\text{Spear Head}}}{\text{Average}_{\text{Spear Head}}} \quad (3)$$

The above formula shows the level of deviation among participants‘ response in terms of each technology type regarding different component of RAL model. After calculating the coefficient of variance (CV) for different type of technology, the next step is to calculate risk level in partial and in total. The following formula is used to calculate the partial and total risk of technology:

$$TotalTK\ \underset{c_1,c_2,c_3,c_4}{risk}\ (RMS) = \sqrt{\sum_{c_1,c_2,c_3,c_4}\left[\left(\sum_{b_1,c_1,sh} Coef.Var_i\right)^2\right]^2} \quad \left.\right| \quad c_1: \text{Quality}, c_2: \text{Time}, c_3: \text{Cost}, c_4: \text{Flexibility}$$

$$Partial \left\{ \begin{array}{l} TK\ \underset{c_1,c_2,c_3,c_4}{risk}\ Basic\ (RMS) = \sqrt{\sum_{c_1,c_2,c_3,c_4}\left[\sum_b \left(\frac{std_i}{mean_i}\right)^2\right]^2} \\ TK\ \underset{c_1,c_2,c_3,c_4}{risk}\ Core\ (RMS) = \sqrt{\sum_{c_1,c_2,c_3,c_4}\left[\sum_{core} \left(\frac{std_i}{mean_i}\right)^2\right]^2} \end{array} \right\} \quad (4)$$

$$\left(TK\ \underset{c_1,c_2,c_3,c_4}{risk}\ Sh\ (RMS) = \sqrt{\sum_{c_1,c_2,c_3,c_4}\left[\sum_{sh} \left(\frac{std_i}{mean_i}\right)^2\right]^2} \right)$$

When all the risk is calculated, next step is to calculate sustainable competitive advantage (SCA) index, using the following formula:

$$TotalRisk(Geom) = [(1 - SCA)TKrisk]^{\frac{1}{2}} \quad (5)$$

$$TotalSCArisklevel = 1 - TotalRisk(Geom) \quad (6)$$

4 Case Studies and Data Collection

The data and cases which are presented in this study are gathered during the student work shop in Warsaw University of life science in Poland. The data which are presented here, are based on high tech startup companies and the decision in which technology focus is crucial in their success. Additionally, they have limited resources as startups and resource allocation plays critical role in setting their strategy. Considering all above, cases are presented here are fit to examine the proposed method here.

During case studies, different group has started the data collection step by defending main attributes in project (regarding project goal and its mission). Then the next step is to estimate these main criteria in terms of different technology share (basic, core, speared). When the data is gathered, final stage is to calculate the variability of coefficient and risk level and to examine how improvement plan might affect the risk of technology deployment.

5 Results

5.1 Case 1: establishing a new transportation company based online scooter

The mission of this start up is to offer high quality and environmental friendly transportation services for customer and having fun simultaneously. The business model of this start up is as follow: customer can rent a scooter on the station via app and they can leave it whenever they want. Since the process of renting works with net and online application, therefor it is very easy and accessible. Customers are charged based on minutes while the starting three minutes is considered free of charge especially for preparation. No driving license is needed for driving scooter and only ID card is enough. There is promotion for long term contact and you can have a friend (or company) with you using the scooter each time. This starts up has the following partners: manufactures of scooters, leasing company, local government, advertising company and eco-friendly organizations. Customer target group are: people who follows environmental friendly life style, passengers in rush, people who likes using technology in everyday life. The core idea behind this start up is to offer rental high-quality scooter for a short period of time. This business needs some spearhead technology (advance technology) such as: stations with sun panels and tablets with navigation system. The current competitive priorities for company are: safety and flexibility, availability and cost. And in future it slightly changes to: safety and cost, 2. availability and flexibility. Manufacturing business strategy index for past and for future is presented in the following table:

Table 4 Manufacture Business Strategy for Scooter Starts Up, in Past and in Future

	Cost	Quality	Delivery	flexibilty	Inconsistency
Past	0.074	0.513	0.138	0.275	0.004
Future	0.275	0.513	0.138	0.074	0.004

The source of uncertainty in term of technology is presented in the next figure. As the pictures demonstrates, spearhead technology reflects the highest level of uncertainties in technology and knowledge decision making process.

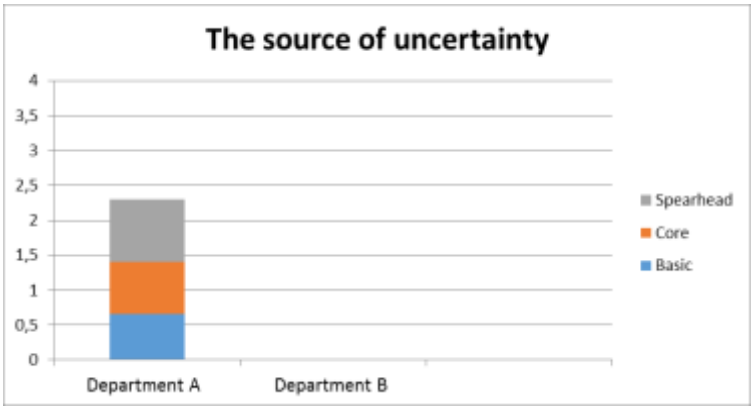

Figure 2 The Source of Uncertainty in Technology Type, Current Situation

Considering the available resources and company main goal and to decrease the level of uncertainty the following improving plan has been suggested: 1. to locate ten rental stations in the city center containing five scooters at each, 2. Customers could return the scooter at the station free of charge otherwise there is extra charge in case of leaving scooter somewhere else in the city. 3. Constantly observe the availability and the location of demand and relocate station to more popular areas if needed. After implementation the improvement plan, the source of uncertainty would look as follow:

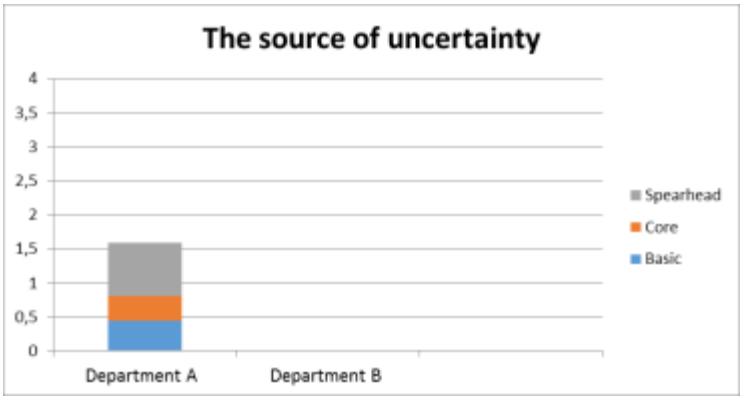

Figure 3 The Source of Uncertainty in Technology Type, after Improvement Plan

Comparing figure 2 and 3 shows that total uncertainty decreases by 25% after improvement plan. While spearhead technology holds the biggest share of risk and uncertainties in past and after improvement plan. Following the formula 1-6 the partial and total risk of technology would be as follow:

Table 5 The Summary of Risk Level

	Technology and Knowledge risk			Total risk (Geom)	Total SCA risk level
	Basic	Core	Spearhead		
Past	0.66	0.74	0.88	1.33	0.36
Future (after improvment plan)	0.45	0.35	0.78	0.97	0.31

The following bar charts show the source of risk and uncertainties in technology deployment has changed after implementation of improvement plan.

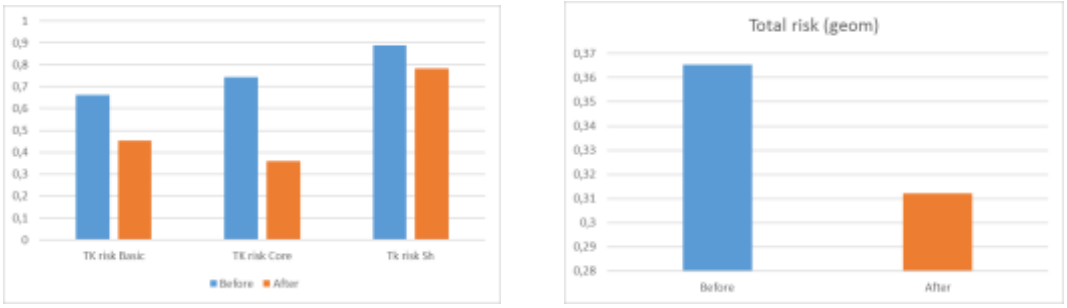

Figure 4 Comparison of Risk Share in Terms of Each Technology, Current (before) and Improved (after)

Having searched the source of uncertainty among sense and respond attribute, the following criteria are detected as critical before suggestion of improvement plan: (1) Training and development of company‘s personnel

(2) Short and prompt lead time in order-fulfilment process

(3) Reduction of unprofitable time in process

(4) On-time delivery to customer

(5) Control and optimization of all type of inventories After improvement plan, the critical attribute would be:

(1) Code of conduct and security of data and information

(2) Information system supports the business process

(3) Visibility of information in information system

(4) Quality and reliability of information in information system

(5)

5.2 Case 2: establishing an entertainment start up based on portable scape room idea

The core idea behind this start up is that the group of people enter to a space room (in here truck trailer) and in order to find the exit way, they need to solve a mystery. This scape room is portable and is able to reach to customer place. This entertainment vehicle is suitable for all the ceremony like wedding, birthdays, parties and all sort of events which people needs to be entrained. The spearhead technology in this start up is ―holographic design‖ while truck could be considered basic technology and advertisement channel is core technology. The business strategy priorities for this company are: (1) quality.
(2)delivery, (3) flexibility and 4. cost. They are presented in the following table:

Table 6 Company Competitive Priorities in Past (before improvement plan)

	Cost	Quality	Delivery	flexibility	Inconsistency
Past	0.057	0.499	0.284	0.160	0.004

Technology and knowledge requirement of this company is filled by seven respondants mainly from marketing, design and logistic department and the results is presented in the following:

Table 7 Knowledge and Technology Share- before Improvement Plan

No	Quality			Flexibility			Cost			Delivery		
	Basic	Core	Spearhead	Basic	Core	Spearhead	Basic	Core	Spearhead	Basic	Core	Spearhead
1	80	20	0	30	50	20	60	30	10	80	20	0
2	20	40	40	15	63	22	30	50	20	10	70	20
3	20	50	30	10	70	20	10	60	30	25	35	40
4	10	45	45	0	50	50	10	45	45	20	40	40
5	30	60	10	0	70	30	30	40	30	20	60	20
6	30	60	10	0	70	30	30	40	30	20	60	20
7	80	20	0	30	50	20	60	30	10	80	20	0

Uncertainties related to technology deployment before implementing improvement plan is demonstrated in the following bar chart:

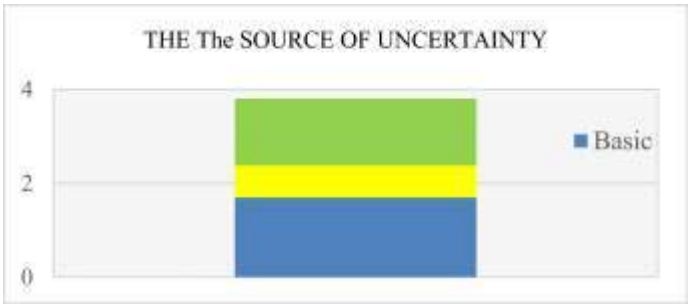

Figure 5 The Source of Uncertainty in Technology Part, Before Improvement Plan

As the bar chat shows, basic and spearhead technology causes the biggest share ofuncertainty in this start up. Some improvement plan has been suggested as follow to decrease the level of uncertainty like: deploy mobile phone app, to increase the truck numbers and projects at least one yearly, corporate with fuel company, offering bonus to customer in case of recommending the company to someone else, and implement customer satisfaction survey constantly. After the improvement plan, knowledge and technology requirement for each type of technology would be as follow:

Table 8 Knowledge and Technology Share-after Improvement Plan

No	Quality			Flexibility			Cost			Delivery		
	Basic	Core	Spearhead	Basic	Core	Spearhead	Basic	Core	Spearhead	Basic	Core	Spearhead
1	30	60	10	30	50	20	20	60	20	80	20	0
2	30	50	20	15	63	22	30	50	20	70	15	15
3	20	50	30	10	70	20	10	60	30	75	15	10
4	20	50	30	10	50	40	10	45	45	60	20	20
5	30	60	10	10	60	30	30	40	30	65	25	10
6	30	60	10	10	60	30	20	50	30	60	15	25
7	40	50	10	20	50	30	30	60	10	80	20	0

And the uncertainty related to each type of technology is presented in the next figure:

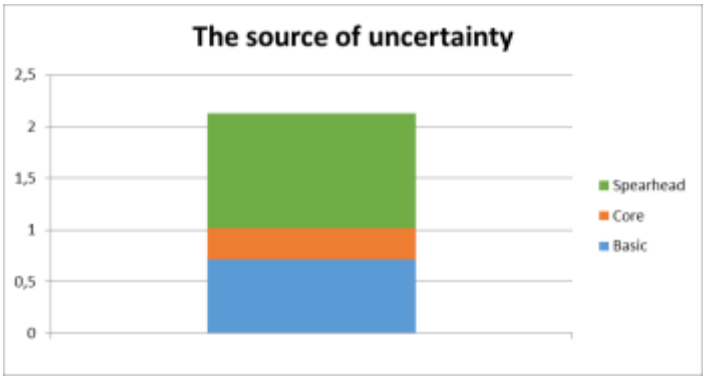

Figure 6 The Source of Uncertainty in Technology Part, Before Improvement Plan

Comparing figure 5 and 6 shows after implementing improvement plan, the main source of uncertainty is spearhead technology.

Uncertainty related to technology and knowledge is presented in the following table:

Table 9 The Summary of Risk Level

	Technology and Knowledge risk			Total risk (Geom)	Total SCA risk level
	Basic	Core	Spearhead		
Past	1.69	0.68	1.4	2.31	0.48
Future (after improvment plan)	0.71	0.30	1.11	1.35	0.37

Having searched the source of uncertainty among sense and respond attribute, the following criteria are detected as critical before suggestion improvement plan:

1.Adoption to knowledge and technology

2.Design and planning the process and product

And after improvement plan, critical attribute would be:

1.On time delivery to customer

2.Quality control of product, process and operation

3.Utilizing different type of organizing system

4.Code of conduct and security of data and information

5.Quality and reliability of information in information system

6 Discussions and Conclusion

This study tries to present a new decision making to evaluate the technology priorities considering business strategy. This tool supports decision makers to decide about technology focus regarding companies‘ business strategy and its internal resource.

The presented SCA model-based knowledge and technology here provides decision maker better tool towards gaining sustainable competitive advantages by making right decision regarding different technology level. The technology decision could be increasing investment or out sourcing for example.

Moreover, the model provides the possibility of:

Observing the right type of operation strategy (cost, quality and time) which could result in company better performance

Investigating which company unit follow company business strategy and which not

Take better strategic action by knowing the criteria which are unbalanced in terms of resource allocation

Companies which are presented here are high tech start-ups. And in both, spearhead technology plays significant role in creating uncertainties. Using this new development tool, these start-ups were able to reduce the risk related to technology deployment for spearhead technology and in total. The proposed model also is connected to sense and respond method which enable companies to detect the focus attribute to maximize their profit regarding company competitive advantage which could be differentiation or cost reduction for example.

Although the effect of technology and knowledge on SCA observed by the proposed model here is not significant, it cannot be neglected. The main role of this paper is to investigate the effect of different technology types on SCA level considering the uncertainties in different technology level.

The analysis and proposed tools are performed on high-tech startups in which technology and specially advanced technology plays significant role. The proposed model in this paper is a suitable tool for decision makers in showing firms‘ strengths and weaknesses and also in detecting the focus area towards gaining sustainable competitive advantage.

Acknowledgement

We would like to thank our colleague Mr. Patrick Zucchetti from university of Vaasa who assisted us greatly in developing previous model of assessing technology and knowledge priorities. The model which is presented in this paper is the development of the previous one.

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