Proceedings of 2013 International Conference on
Technology Innovation and Industrial Management
29-31 May 2013, Phuket, Thailand

USING SUSTAINABLE COMPETITIVE ADVANTAGES TO MEASURE TECHNOLOGICAL OPPORTUNITIES

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ABSTRACT

Purpose: *This paper tries to find operative competitive advantage. The results of this paper help small and medium size enterprises (SMEs) which are striving to export. In fact, this paper introduces a new technique which applies critical factor analysis, risk and opportunities analysis to measure and propose resource allocation for companies in couple of next years.*
Research questions: *In this paper two questions are answered: 1. How to evaluate Knowledge and Technology (K/T) effect on operative Sustainable Competitive Advantages (SCA)?. 2. How the results from calculation Critical Factor Indexes (CFIs), SCA level and K/T are evaluated?*
Design/Methodology/approach: *This research is based on 7 case studies from Oulu South region of Finland. The cases were selected from manufacturing industry including cases focusing on manufacturing of wood product, machinery and equipment, and instruments and appliances. In this research paper, the effect of technology and knowledge on SCA risk level is investigated. In other words, here this question is answered: what would be the effect of T/K calculation on (Balanced) Critical Factor Index changes.*
Findings: *The effect of Knowledge/Technology(K/T) on (Balanced) Critical Factor Index changes depending on the proportions allocated among the different technological levels (Basic, Core or Spearhead) for each attribute separately. Therefore, the effect of K/T may be analyzed by taking the dominating technology and the resource allocation into consideration for each attribute respectively.*

Research limitations/implications: *in this research paper, 7 case studies are investigated. For 6 of them, at least 2 respondents are interviewed. However in one case, there is only one respondent. So in this case, the calculation of CFI factor is not possible. Moreover, as the number of respondents of each case is not big, so it is not possible to eliminate the effect of standard deviation in calculation of CFIs factor.*
Practical implications: *This research helps firms to take balance in resource allocation for each attribute in changing environments on the basis of different level of technology (Basic, Core or Spearhead).*

Key words: Sense and response methodology, Sustainable competitive advantage (SCA) model, Risk level, knowledge and technology (K/T), Oulu South region, Small- and medium –sized enterprise (SME).

Originality/Value: this paper presents the 'first in the world' case study on operative sustainable competitive advantage and corresponding risk levels by taking into account technology and knowledge effects for 7 SME companies.

INTRODUCTION

The world is changing every day and this unstable situation influences on business in huge scale. Among this turbulent environment, operation strategy is one of the most essential tools which can helps manages to save their position or even get more share in global market. According to Si, Takala and Liu (2010),"The future competitiveness of manufacturing operations under dynamic and complex business situations relies on forward-thinking strategies". In fact, companies should have multifocused strategy at the same time and try to consider competitive priorities consist of time, quality, cost and flexibility according to market analysis.

Sustainable competitive advantages (SCA) notion was defined by Porter 1985 for the first time and it has evolved slowly from then. In 1991, Barney completed it as: A firm is said to have a sustained competitive advantage when it is implementing a value creating strategy and when these other firms are unable to duplicate the benefits of this strategy".

Later in 2001 Barney developed his definition and introduced SCA as a resource base theory. The core concept behind resource based strategy is that if a firm is to achieve a state of SCA, it must acquire and control valuable, rare, inimitable, and nonsubstitutable resources.
Marone (1989) believes that considering technology provides some opportunity for firm in the process of decision making and setting strategy for future. So Knowledge and Technology is included in sense and respond questionnaire to calculation SCA levels.

In this paper the effect of K/T factor on SCA level is investigated. The paper tries to answer two questions: 1. How to evaluate K/T effect to operative SCA?. 2. How the results from calculation CFIs, SCA risk level and K/T are evaluated?
In order to answer the questions, seven case companies from Oulu region of Finland are investigated, from each case company; at least 2 respondents are interviewed. Only in one case company (C), one respondent is interviewed.

This paper introduces a short literature review to the topic and some background information about the case companies. In the next part, general results of including K/T factor on SCA risk level are presented. Then the results of weak market test (WMT) are presented to show how this model meets reality. In next stage, Company E which shows good condition according to WMT is investigated in detail. Finally, discussion about the question and conclusion come.

THEORY BACKGROUND

1. Manufacturing strategy:

Quinn (1980) defines strategy as "the pattern or plan that integrates an organization's major goals, policies and action sequences into a cohesive whole". A well-formulated strategy helps marshal and allocates an organization's resources into a unique and viable posture based upon its relative internal competences and shortcomings, anticipated changes in the environment, and contingent moves by intelligent opponents. From then, the concept of strategy evolved in such a way that nowadays this concept; also include a corporate social responsibility and new models of leadership (Grant, 2005).

It should be mentioned here that there is a significant different between corporate strategy and business strategy. In fact, corporate strategy means overall business portfolio, acquisitions, divestments, joint ventures and major reorganizations while business strategy defines single business or product line strategy. The following picture shows the differences between these two concepts (Daft, 1986: 476-477):

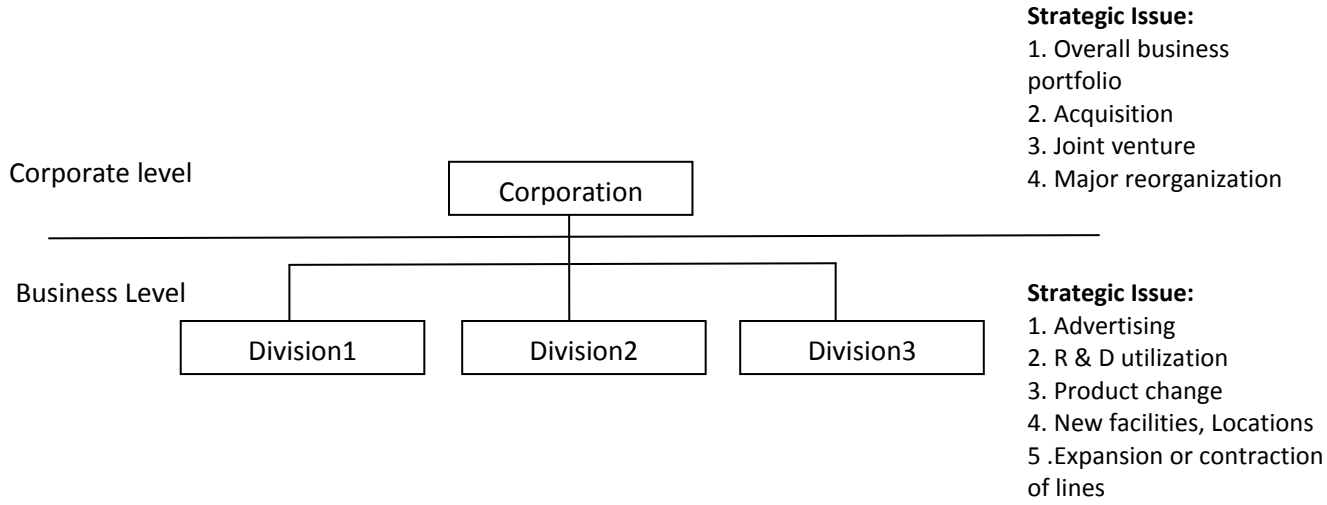

Figure1.Hierarchy of corporate and business level strategies (Daft, 1986: 477)

A long with the strategy definitions, several archetypes or topologies have been proposed to define the decisions and directions that managers implement in their organizations.
On of the most famous strategy topology is defined by Michael Porter in year 1980. In his model, he defines three generic enterprise strategies as (Porter, 1980: 34-40):

- Overall cost leader ship
- Differentiation
- Segmentation

Another famous strategy topology is defied by Miles and Snow. Miles and Snow´s competitive strategies divide the business strategies on to four groups (Daft, 2009):

- Defender: concentrates in a mature product or market operation. This strategy focus on efficiently and prefer not to take risk . in this type of strategy company tries to strengthen efficiency and maintain their current costumers.
- Prospector strategy: looks forward to new opportunities in market. This strategy is dynamic and tries to innovate in processes and take risk. Besides, this type of strategy focus to lead it's industry.
- Analyzer strategy: is placed between the defender and prospector strategy and tries to conserve a steady state in market.
- Reactor strategy: is no-strategy and happens in absence of defined goals and objectives. In this type of strategy, decisions are taken to respond immediate problems as there is no sense of direction.

According to Daft (1986: 480) the choice between these alternatives depends on the current product life cycle and how does the management interpret the external environment. There are three main problems, which drives the companies to make decisions among these possibilities: Entrepreneurial, engineering, and administrative problems (Daft 1986: 481). Differences between these different company types are listed in the table below:

Table 1.Strategy types: (Daft 1986: 481, Miles, Snow, Meyer & Coleman Jr., 1978: 557-558).

Characteristic	**Defender**	**Analyzer**	**Prospector**	**Reactor**
Environment	Stable	Moderately Changing	Dynamic, Growing	Any condition
Strategy	Seal Off share of market Protect tuff. Advertise to hold customer	Maintain market but innovative at edges. Locate opportunities for expansion while protecting current position	Find and exploit new market opportunities. Scan environments. Take risk.	Not clear strategy . React to specific condition. Drift.
Internal characteristic	Efficient production. Retrench	Efficient production yet flexibility for	Flexible production. Innovation and	Now clear organization approach.

Characteristic	Defender	Analyzer	Prospector	Reactor
	tough control. Centralized mechanistic	new lines. Tight control over current activities. Looser for new lines.	coordination. Expansion. Centralized organic.	Depends on current needs.

Madu el al (1996) introduced a technology path for different technology level. This model is completed by Takala later. The idea behind this model is that when a company starts to sell its product. It moves from Technology specialist to commodity product, collaboration partner and problem solver step by step. This concept shows in following picture (Takala, Hirvela¨ and Liu):

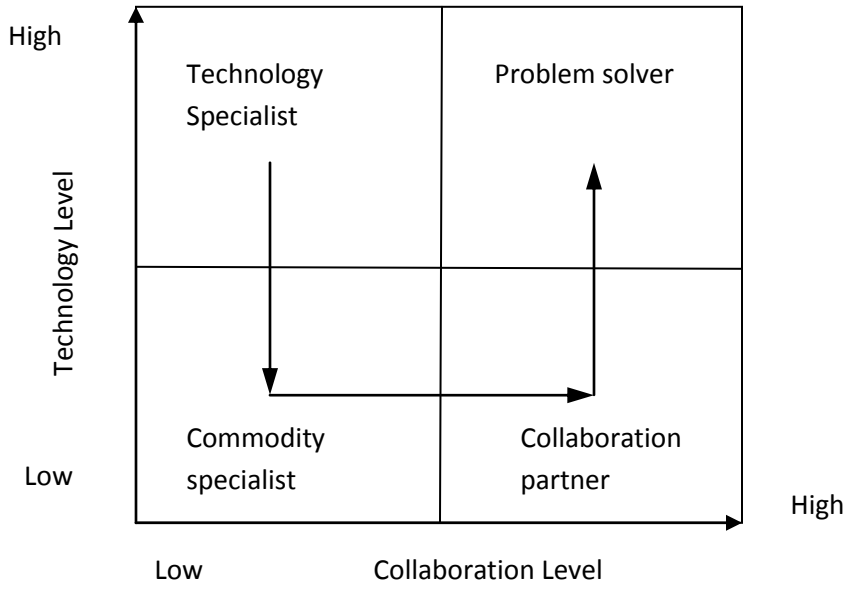

Figure2.Technology path: modified from et al. (1996)

A manufacturing strategy based on a business strategy includes three objectives: competitive priorities, manufacturing objectives and action plans. In other words, first competitive priorities for a company are defined. Then, regarding to competitive priority manufacturing strategy are defined. Finally in last step, suitable action plan to achieve strategic goal is defined and implemented. The following picture shows this process model (Kim and Arnold. 1996):

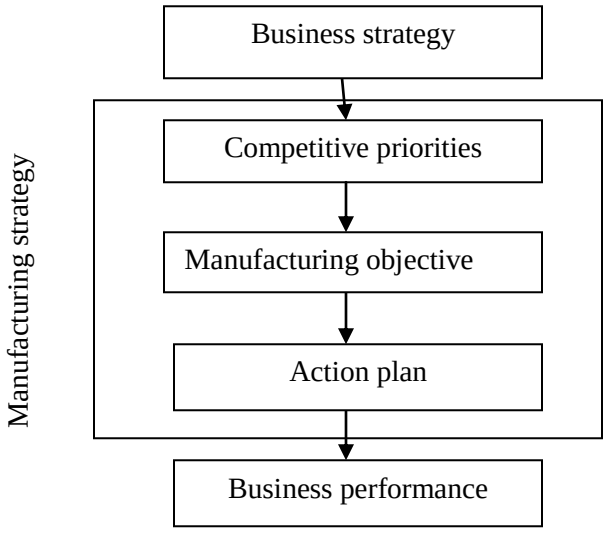

Figure3.Process model of manufacturing strategy, Kim and Arnold(1996)

2. Resources based view of the firm:

Barney et al(2001), suggest sustainable competitive advantages as a resource- based strategy. The core concept behind resource based strategy is that if a firm is to achieve a state of SCA, it must acquire and control valuable, rare, inimitable, and nonsubstitutable resources. Moreover, this firm should have an organization can absorb and apply them (Jeroen Kraaijenbrink, J.-C. Spender and Aard J. Groen,2010). It should be emphasized here that technology as know-how, is a relevant part of resource based strategy (Braun, 1998; Takala, 1997).

Wernerfelt (1984), suggests that analyzing a firm from the resource side has more benefit rather than from the product side.In fact, he believes that the resources and the product should be taken to account at the same time and finding optimal product market activities is possible by specifying a resource profile for a firm.

METHODS

1. AHP, questionnaires, data collection and analysis

According to Saaty 1980,"The Analytic Hierarchy Process (AHP) method is a multi-attribute decision instrument that allows considering quantitative, qualitative measures and making tradeoffs"(Yang Liu and Josu Takala).

The data of case company are collected by asking managers or people from managements group to answer the questionnaires from different departments. The interviewees are normally decision makers and middle management groups in the case company, who understand the operations of the company, and the number of informants is dependent on the size of the case company. The interviewed high competence experts should be representative to know well the operations of the studied case company.

2. CFIs, Sense and respond

The sense & respond model is used to help in dynamic decision-making to describe, evaluate, benchmark and optimize lower level resource allocations to meet the performance requirements in all the interest groups inside and outside the organization and in turn to improve higher level strategies. The critical factor index (CFI) method is a measurement tool to indicate which attribute of a process is critical and which is not, based on the experience and expectations of the interviewees. The S&R model has gone through three stages of development, which are called CFI model, BCFI model, and SCFI model.

3. Manufacturing strategy

The analytical models for manufacturing strategy are used to calculate the operational competitiveness indexes of companies in different competitive groups, namely prospector, analyzer and defender. The manufacturing strategy index (MSI) is modeled based on the multi criteria priority weights of Q (Quality), C (Cost), T (Time/delivery) and F (Flexibility), as function $MSI = f_{MSI}(Q, C, T, F)$.

Figure 5 shows different position of a firm considering operation strategy. In this picture, prospectors are constantly seeking for new market and product innovations. They create instability in the market. Prospectors are concentrating in quality so they are not as cost-effective as defenders. Analyzers work both static and dynamic markets. In static markets they seek to operate as cost-effective as possible and in dynamic markets they are observing their competitors and try to adapt most promising ideas. Defenders work at narrow market areas and they have narrow product portfolio. Defenders are concentrated to intensify their existing processes and they don't seek new product and market innovations.

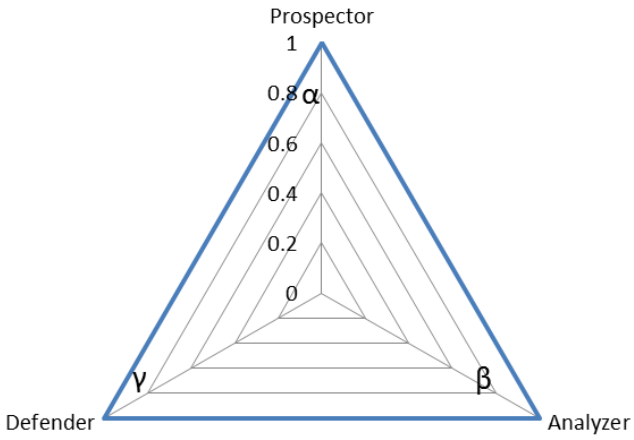

Figure4: Manufacturing strategy

4. SCA, MAPE, RMSE, MAD

Sustainable competitive advantage (SCA) is the measurement of risk level for that the operation strategy should be improved to sustain the operation competitiveness during the period considered. There are three indexes, which are MAPE, RMSE and MAD, to measure the risk level of the operation strategy for sustainable competitive advantages in this paper.

5. Technology Rankings, BCFI K/T

Knowledge/Technology requirement section has been added to the Sense and Response questionnaire to gather information about the companies' knowledge/technology rankings. Basic technology is referring to technologies commonly used and that can be purchased or outsourced, Core technology is referring to company's current competitive technologies and Spearhead technology is referring to the technologies focused on the future. Each attribute in the list is numbered and analyzed in graphs with respect to the order. The importance of different technological levels (Basic, Core or Spearhead), in technology-based businesses, affects a lot the strategy implementation by the knowledge required, and supports the company's success in the competitive category chosen. The attributes are assigned to one of the multiple key categories of RAL model Quality (Q), Cost (C), Time/Delivery (T) and Flexibility (F), depending on their most significant effect.

CASE INTRODUCTION

Oulu South region:

Oulu South Area is located in Northern Ostrobothnia in the southern part of the province of Oulu. It has three sub-region area of cooperation. The area includes a total of 14 municipalities with a total population of just under 90 000, or about a quarter of the Northern Ostrobothnia population. In 2001, Oulu Southern Regional Ministry of the Interior approved the regional center program three sub-region network-type cooperation area. The region's development strategy has been prepared in Oulu South 2015 agreement. The contract shall be entered in the main area of development in 2007-2015.

Oulu South is one of the main agricultural areas - the area can be characterized as an industrialized in rural areas, because the region offers a significant extent, the manufacturing industry jobs. The largest industries are agriculture, metals, wood products industry, and information and communication technology (ICT). The regional unemployment rate is among the lowest in northern Finland and the age structure of the population is young. This differentiates from other Finnish Oulu Southern rural areas. Oulu South is a business-friendly area where currently about 4,600 active companies. Of these, about 95% of companies are micro-enterprises.

RESULTS

1. The result of including K/T factor on SCA risk Level

The following tables shows how calculating K/T factor effect on SCA risk level:

1.1 SCA risk level in past without K/T:

Table 2.SCA risk level for Oulu South region (Past)

Past	A			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.95	0.88	0.87	
RMSE	0.96	0.92	0.92	
MAD	0.97	0.94	0.94	

Past	B			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.95	0.88	0.87	
RMSE	0.96	0.92	0.92	
MAD	0.97	0.94	0.94	

Past	C			
	CFI	BCFI	SCFI	BCFI T/K
MAPE		0.94	0.92	
RMSE		0.96	0.95	
MAD		0.97	0.96	

Past	D			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	1.00	0.95	0.91	
RMSE	1.00	0.97	0.94	
MAD	1.00	0.97	0.95	

Past	E			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.90	0.87	0.90	
RMSE	0.94	0.92	0.94	
MAD	0.95	0.93	0.95	

Past	F			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.98	0.91	0.92	
RMSE	0.99	0.94	0.95	
MAD	0.99	0.95	0.96	

Past	G			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.90	0.88	0.89	
RMSE	0.94	0.92	0.92	
MAD	0.95	0.94	0.94	

According to the above table, almost all the risk levels are less than 0.10 which means that the company operation strategy is sustainable. Only in three cases (one from case A, one from Case B and two from Case G) risk level is a little more than 0.10 which is not significant considering all the good results.

1.2. SCA risk level in future considering K/T

The following tables show the effect of K/T calculation on SCA risk level in future:

Table 3.SCA risk level for Oulu south region considering K/T (Future)

Future	A			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.88	0.98	0.98	0.80
RMSE	0.93	0.99	0.99	0.88
MAD	0.94	0.99	0.99	0.90

Future	B			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.88	0.98	0.98	0.80
RMSE	0.93	0.99	0.99	0.88
MAD	0.94	0.99	0.99	0.90

Future	C			
	CFI	BCFI	SCFI	BCFI T/K
MAPE		0.94	0.93	0.94
RMSE		0.96	0.95	0.96
MAD		0.97	0.96	0.97

Future	D			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.96	0.91	0.95	0.90
RMSE	0.97	0.95	0.97	0.94
MAD	0.98	0.96	0.97	0.95

Future	E			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.88	0.88	0.84	0.83
RMSE	0.93	0.93	0.90	0.90
MAD	0.94	0.94	0.92	0.92

Future	F			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.83	0.97	0.97	0.94
RMSE	0.90	0.98	0.98	0.96
MAD	0.91	0.98	0.99	0.97

Future	G			
	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.76	0.79	0.79	0.81
RMSE	0.85	0.87	0.87	0.88
MAD	0.89	0.90	0.90	0.91

According to all the tables above, calculating K/T affects the risk levels. Means that considering K/T factor dose not reduce SCA risk level. In more details, in four cases company contain A, B, D and F the SCA risk level increased after adding K/T factors. In C and G Company the risk level decreased but it is not significant and In case E, SCA risk level stays almost unchanged after adding K/T factor.

1.3. Weak Market Test (WMT):

In order to understand how the calculated results meet the reality the weak market test (WMT) is conducted by interview managers from each company. This new interview is conducted by phone or face to face meeting.

Table4. The results of WMT

	Company Name:	**Main Activity/ Industry**	**Informants**	**Interview by: phone/Meeting**	**WMT results with all the results of MSI, DEA, S&R, SCA**
1	G	Automation for Mechanical wood industry Civil engineering	Managers	Phone	As expected, OP management too dependent on Manager. Justifies their pre - understanding in a useful manner
2	C	Sawmill	Manager and two persons from management group	Meeting	As expected, very exact result and something new. Verifies the roots of decision making capabilities.
3	F	Mechanical wood products	Manager	Meeting	Accepted
4	E	Manufacturing of sports goods	Manager	Phone	Extremely good, fit of the findings within Operations strategy and sustainable competitive advantage
5	B	Electronics and software	Manager	Meeting	No contradiction with the situation in the operative level Uncertainty and Challenge with the General strategy and ownership

Unfourtuanly, we could not interview the managers from A and D company in this step so the results of WMT is not available.

2. The results of CFIs and T/K calculation for Company E in detail:

In following parts, the results of company E which shows a good condition according to weak market test is explained in detail:

2.1. Expectation VS Experience:

It demonstrates the comparison between the experiences and expectations of the respondents in Figure 5. According to this figure, the average of expectation is more than the average of experience and it means that the company plans to improve the level of different criteria for future.

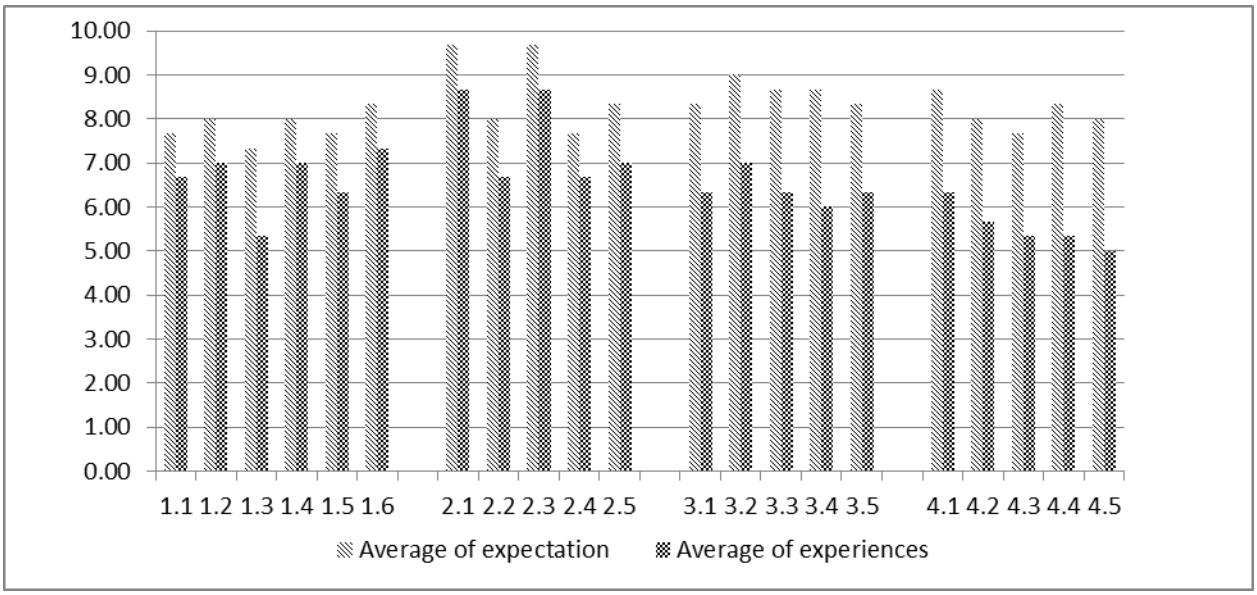

Figure 5: Detection of the attributes for future competitiveness

2.2. Critical Factor Index (CFIs), Operation Priorities

There are three different colors defined for the resource allocation of the attributes: red, yellow and green, which represent whether an attribute is under resourced, over resourced or balanced. Here the resource allocation of the attributes is considered to be ideal if it is equally distributed. The whole resource is counted to be 100% and it is divided to the total number of attributes. By this division the average resource level is defined. An attribute is counted to be balanced and takes the green color if CFIs value is between the range of 1/3 and 2/3 of average resource level. For the rest, any attribute which has a lower CFIs value than 1/3 of average resource level is counted to be under resourced and takes the red color, and any attribute which has higher CFIs value than 2/3 of average resource level is counted to be over resourced and takes the yellow color (Liu et al, 2012).

Figure 6, shows critical factor index in terms of CFI for future. According to this bar chart, only four attributes are balance resource (the black ones) and sixteen attributes are critical resource (over resources or under resources) in CFI (OP) figure.

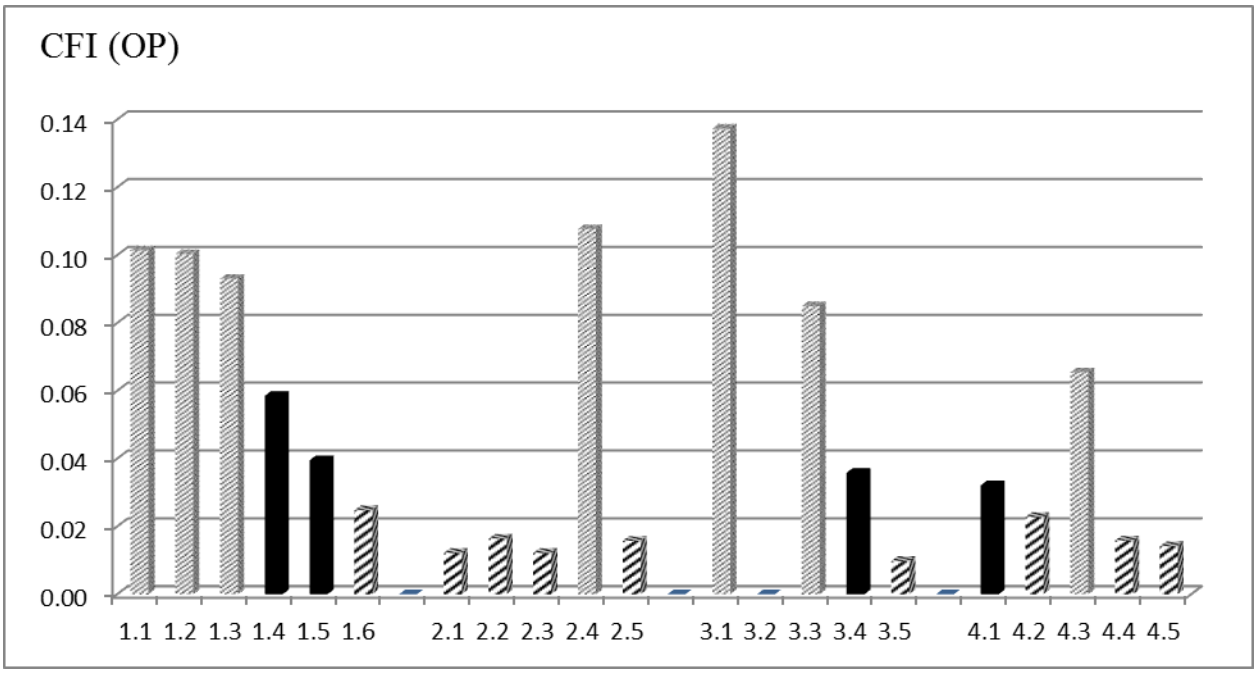

Figure 6: Critical Factors (Operations Priorities)

Next figure shows critical attribute in terms of BCFI. Bar chart shows that three attributes are over (bars with lighter color) and four attributes are under resource (bars with stranger color) in BCFI (OP) figure.

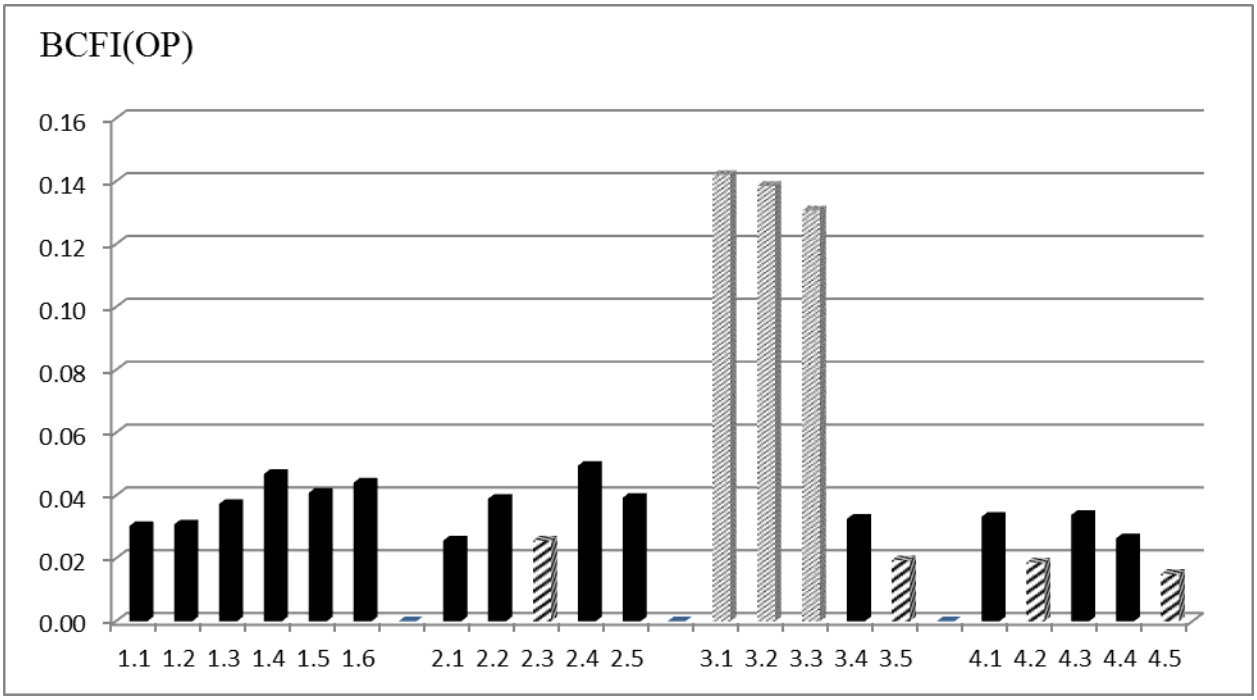

Figure 7. Balanced Critical Factors (Operations Priorities)

Figure 8, shows critical attribute in terms of SCFI calculation. It shows that five attributes are over and seven attributes are under resource in SCFI (OP) figure.

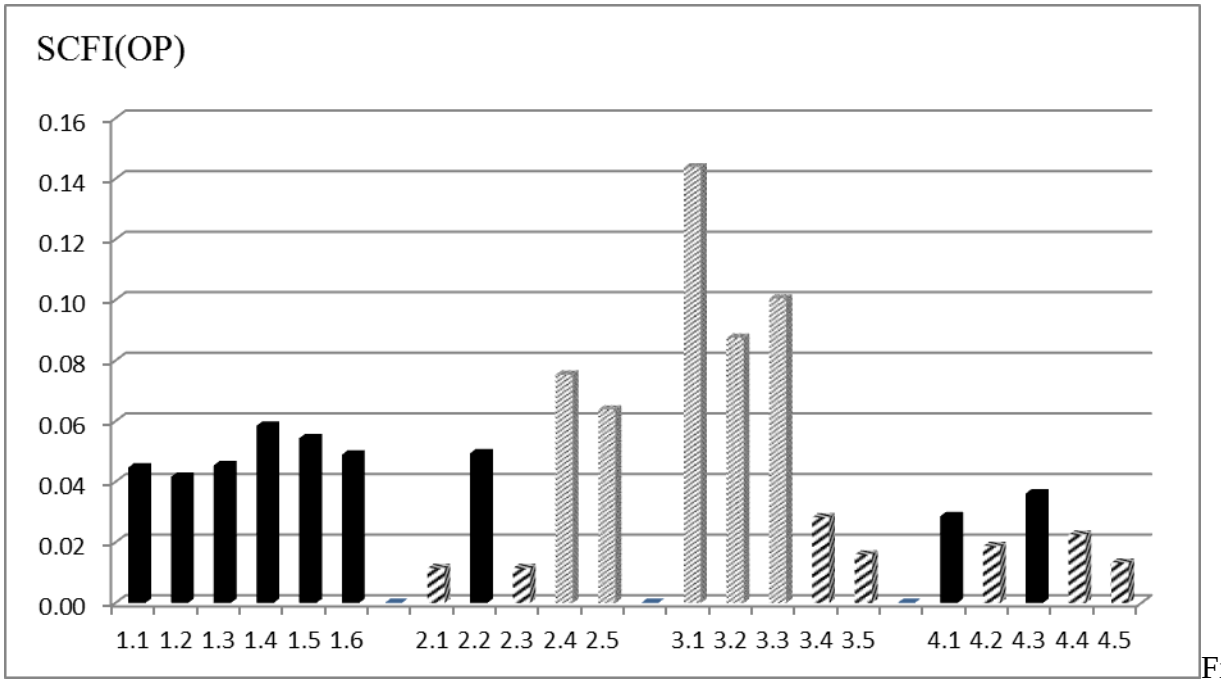

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Figure 8. Scaled Critical Factors (Operations Priorities)

2.3. SCA calculation

In table 5, the PAD (prospector, Analyzer, Defender) values for both past and future competitive strategy are calculated based on CFI. In past strategy, the PAD value for prospector is 0.89, for analyzer is 0.93 and for defender is 0.92. In future strategy, the PAD value for prospector is 0.89, for analyzer is 0.94 and for defender is 0.91.

Tabale5.SCA value (CFI)

	prospector	Analyzer	Defender
Past	0.89	0.93	0.92
Future	0.89	0.94	0.91

In table 6, PAD values for both past and future competitive strategy are shown based on BCFI. In past strategy, the PAD value for prospector is 0.90, for analyzer is 0.96 and for defender is 0.92. In future strategy, the PAD value for prospector is 0.91, for analyzer is 0.95 and the angle for defender is 0.91.

Table6. SCA values (BCFI)

	prospector	Analyzer	Defender
Past	0.90	0.96	0.92
Future	0.91	0.95	0.91

In table 7, PAD values for both past and future competitive strategy are shown on the basis of SCFI. In past strategy, PAD value for prospector is 0.89, for analyzer is 0.94 and for defender is 0.92. In future strategy, the PAD value for prospector is 0.90, for analyzer is 0.98 and for defender is 0.91.

Table7. SCA values (SCFI)

	prospector	Analyzer	Defender
Past	0.89	0.94	0.92
Future	0.90	0.98	0.91

In Table 8, the SCA risk level (for past and without the effect of K/T) is measured by the MAPE, RMSE and MAD based on the CFI, BCFI and SCFI.

Table 8: SCA Risk Level (past)

	CFI	BCFI	SCFI
MAPE	0,90	0,87	0,90
RMSE	0,94	0,92	0,94
MAD	0,95	0,93	0,95

In Table 9, the SCA risk level (for future and including the effect of K/T) is measured by the MAPE, RMSE and MAD based on the CFI, BCFI and SCFI.

Table 9: SCA Risk Level (Future)

	CFI	BCFI	SCFI	BCFI T/K
MAPE	0.88	0.88	0.84	0.83
RMSE	0.93	0.93	0.90	0.90
MAD	0.94	0.94	0.92	0.92

2.3. Knowledge and Technology (K/T) effect:

In general the company's current competitive technologies (Core Technology) seem to be around 40%, the technologies commonly used (Basic Technology) are around 40% and the technologies focused on the future (Spearhead Technology) are around 20% for most of the attributes (Figure 10). From technology rankings point of view the company is found to be competitive one and aims to follow a positive slope in case of technology as it is aiming to improve it in future case.

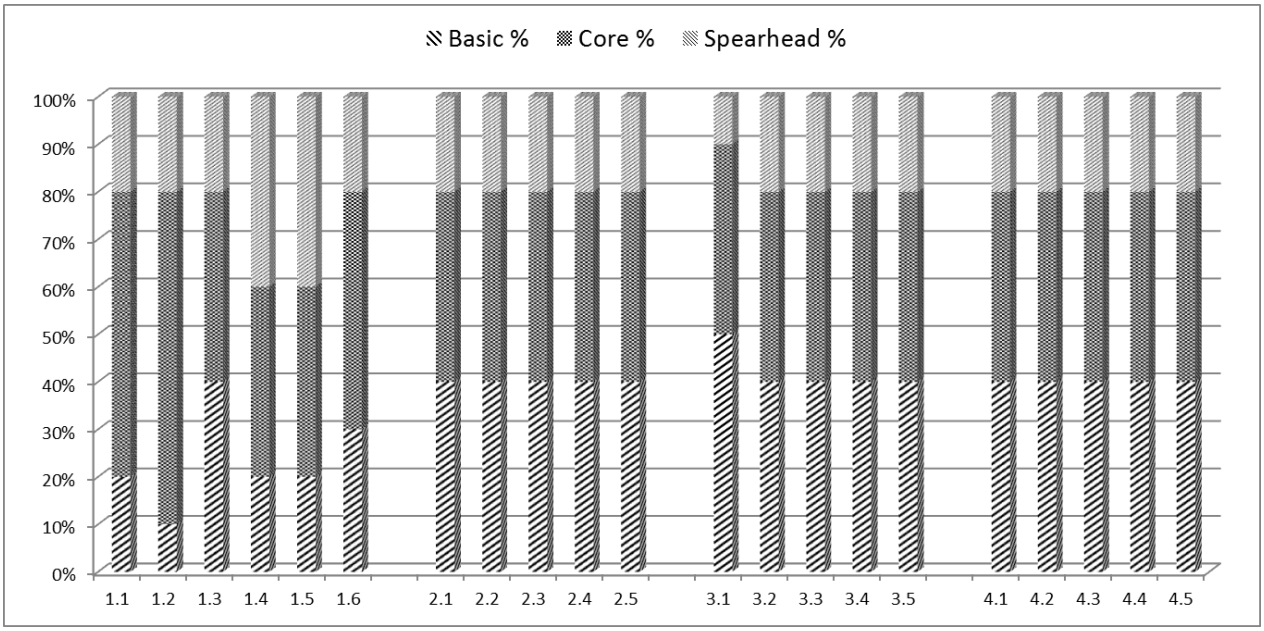

Figure 9: Technology and Knowledge

In Figure 10, the red bars represent the knowledge/technology based BCFI values and other bars stand for traditional BCFI values. From the technology point of view, the attributes number 2.2, 2.4, 2.5, 3.1, 3.2, 3.3, 3.4 seen to be over resourced in terms of BCFI TK, these attributes are observed to be less critical compared to BFCI values, for some attributes are more critical.

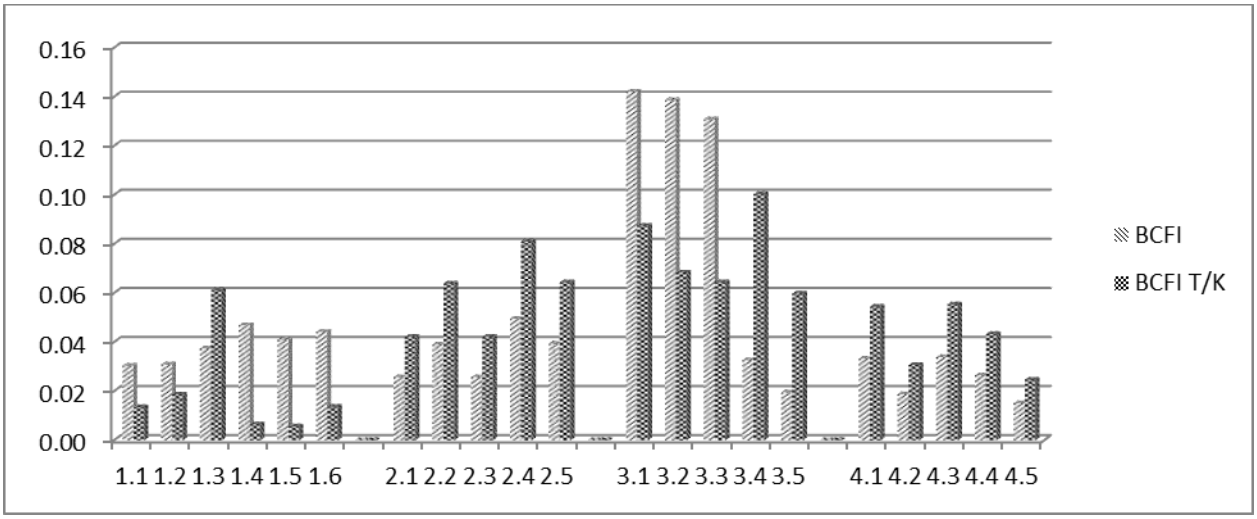

Figure10: BCFI and BCFI T/K

DISCUSSION

In this paper seven case companies from Oulu South region of Finland are investigated to answer two questions:

First question seeks to find the effect of K/T factor on SCA risk level. Investigation these seven case companies' shows that including K/T factor dose not decrease the SCA risk level in general. In fact, including K/T calculation enhances the risk level only in case C and G just a bit. But this amount of enhancement is not significant. In only one case (E) SCA risk level stays almost unchanged after adding K/T factor and for the rest of cases consist of A,B, D and F risk level increased after adding K/T factors .

Second question focus on evaluation of CFIs calculation, SCA level and K/T factor. To answer this question one case company (E) which shows good condition according to WMT (and results of calculation meet the reality well), is investigated in detail. The following results are obtained: first: investigation of case E shows that including K/T in BCFI calculation, does not guide attribute to more or less critical places in general. In other words, for some attribute BCFI K/T shows more critical position compared to BCFI and for some of them BCFI K/T shows less critical position compared to BCFI(no specific direction). Second: the strategy of case E is sustainable. In other words, there is not any significant difference between the result of SCA level in past and future and all of the SCA levels show the position of Analyzer for company E in past and future. This result can be very useful for managers and shows them if in future the company wants to get the position of prospector and lead the market they need and should to invest on the resources which are related to quality otherwise in best condition they can only save this current position for future.

CONCLUSION

The study of sustainable competitive advantage is essential – it uses the Sensing and Responding methodology to finding critical factors in experiences and expectations. The study presents methodology which evaluates the effect of K/T to SCA risk level by taking resource allocation to consideration. Moreover this methodology ensures that the various resources of the organization are operating in accordance with common strategy. The value of the methodology is in its ability to make the structure of the organizations and strategies transparent for developing actions. General finding of the development work is an importance of information technology for the target organization and transformational leadership for proactive preparedness.

In summary, the results of weak market test for 5 companies show that in general, this model is applicable in real business world and the outcomes are not far away from mangers exception but in order to validate and test formula for strategic decision making process, more studies and investigation is necessary and this model is still in initial stages.

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APPENDIX

1.The models of CFI, BCFI and SCFI

Name	Model
CFI	$CFI = \frac{Std\{\exp erience\} \times Std\{\exp ectation\}}{\mathrm{Im}\, por\tan ce\ index \times Gap\ index \times Development\ index}$ (1)
BCFI	$BCFI = \frac{SD\{\exp erience\} \times SD\{\exp ectation\} \times Performance\ index}{\mathrm{Im}\, por\tan ce\ index \times Gap\ index \times Development\ index}$ (2)
SCFI	$SCFI = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}[\exp erience(i)-1]^2} \times \sqrt{\frac{1}{n}\sum_{i=1}^{n}[\exp ectation(i)-1]^2} \times Performance\ index}{\mathrm{Im}\, por\tan ce\ index \times Gap\ index \times Development\ index}$ (3)

Parameters:

$$\mathrm{Im}\, por\tan ce\ index = \frac{Average(\exp ectation)}{10};$$

$$Gap\ index = \left|\frac{Average(\exp erience) - Average(\exp ectation)}{10}\right|;$$

$$Development\ index = |0.9 \times (better - worse) - 1|;$$

$$Performance\ index = \frac{Average(\exp erience)}{10};$$

$$SD(\exp erience) = \frac{Std(\exp erience)}{10} + 1;$$

$$SD(\exp ectation) = \frac{Std(\exp ectation)}{10} + 1.$$

2. Calculation of MSI factors:

The equations to calculate normalized weights of core factors are as follows:

$$Q' = \frac{Q}{Q+C+T} \quad (4)$$

$$C' = \frac{C}{Q+C+T} \quad (5)$$

$$T' = \frac{T}{Q+C+T} \quad (6)$$

$$F' = \frac{F}{Q+C+T+F} \quad (7)$$

$$Q = Quality; C = Cost; T = Time/delivery; F = Flexibility.$$

3.The analytical models to calculate the manufacturing strategy indexes of operational competitiveness in each group :

The MSI model for prospector group:

$$MSI_p = 1-(1-Q'^{1/3})(1-0.9T')(1-0.9C')F'^{1/3} \quad (8)$$

The MSI model for analyzer group:

$$MSI_A = 1-(1-F')\left|(0.95Q'-0.285)(0.95T'-0.285)(0.95C'-0.285)\right|^{1/3} \quad (9)$$

The MSI model for defender group:

$$MSI_D = 1-(1-C'^{1/3})(1-0.9T')(1-0.9Q')F'^{1/3} \quad (10)$$

4. Calculation of risk level: Models of MAPE, RMSE and MAD

The equations to calculate risk level are as follows:

Name	Models
MAPE	$MAPE = 1-\sum_{i=1}^{n}\left\|(BS_i - BR_i)/BS_i\right\|$ (15)
RMSE	$RMSE = 1-\sqrt{\sum_{i=1}^{n}[(BS_i - BR_i)/BS_i]^2}$ (16)
MAD	$MAD = 1-\max\left((BS_i - BR_i)/BR_i\right)$ (17)

5. Knowledge and Technology Calculation

$$IMPL\ Basic = \frac{std\ \{Basic\ Technology(\%)\}}{avg\ \{Basic\ technology(\%)\}} \quad (18)$$

$$IMPL\ Core = \frac{std\ \{Core\ Technology(\%)\}}{avg\ \{Core\ technology(\%)\}} \quad (19)$$

$$IMPL\ Spearhead = \frac{std\ \{Spearhead\ Technology(\%)\}}{avg\ \{Spearhead\ technology(\%)\}} \quad (20)$$

$$Technology\ IMPL = \sqrt{\sum(IMPL\ Basic^2 + IMPL\ Core^2 + IMPL\ Spearhead^2)} \quad (21)$$

6. The Criteria used in Questionnaire for Sense and respond method:

	ATTRIBUTES	
	Knowledge & Technology Management	
1.1	Training and development of the company's personnel	← Flexibility
1.2	Innovativeness and performance of research and development	← Cost
1.3	Communication between different departments and hierarchy levels	← Time
1.4	Adaptation to knowledge and technology	← Flexibility
1.5	Knowledge and technology diffusion	← Cost
1.6	Design and planning of the processes and products	← Time
	Processes & Work flows	
2.1	Short and prompt lead-times in order-fulfillment process	← Flexibility
2.2	Reduction of unprofitable time in processes	← Cost
2.3	On-time deliveries to customer	← Quality
2.4	Control and optimization of all types of inventories	← Quality
2.5	Adaptiveness of changes in demands and in order backlog	← Flexibility
	Organizational systems	
3.1	Leadership and management systems of the company	← Cost
3.2	Quality control of products, processes and operations	← Quality
3.3	Well defined responsibilities and tasks for each operation	← Flexibility
3.4	Utilizing different types of organizing systems	← Flexibility
3.5	Code of conduct and security of data and information	← Cost
	Information systems	
4.1	Information systems support the business processes	← Time
4.2	Visibility of information in information systems	← Time
4.3	Availability of information in information systems	← Time
4.4	Quality & reliability of information in information systems	← Quality
4.5	Usability and functionality of information systems	← Quality

7. Model of questionnaire for Sense and Respond method (Takala, Ranta, 2007) :