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THE UNDERLYING RELATIONSHIPS BETWEEN SUCCESS CRITERIA & SUCCESS FACTORS IN NPD ACTIVITIES

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1. Introduction

Developing new products and staying ahead of the competition is critical for the survival of companies in a competitive environment [Talke et al. 2009]. There are many factors affecting a product's chance of success in these environments, such as the company business model, the product type, the company's organisational structure and so on [Trott 2002], [Howard et al. 2011]. When product novelty is not sufficient, what defines a successful development? To answer this question it is necessary to identify what determines a successful New Product Development (NPD) process and how is it measured.

Conceptual and empirical research to identify the critical success indicators (criteria and factors) of NPD processes has been carried out intensively by the research community [Ernst 2002]. Although the importance of measuring NPD success is widely recognized, its treatment remains intangible, due to the multidimensional nature of success, different levels of analysis that can be examined, and multiple stakeholders who look for different values and have different understanding of what success is [Lipovetsky et al. 1997].

One could divide success indicators into two categories: *success criteria*, which encompass the means to measure, judge or decide about product/project success as presented in [Kazerouni et al. 2011]; and *success factors*, which are the facts and situations that influence the outcome of the NPD process and can be used as an input to the managers and management systems to eventually result in successful NPD projects [Cooke-Davies 2002].

NPD is a set of cross-functional activities, involving a wide range of stakeholders (people, companies, etc.) working together to achieve successful new products on the market. These stakeholders might not equally agree upon the importance of criteria in measuring project/product success during its pre-completion, short-term, medium-term and long-term perspectives. These differences in understanding and perceiving the importance of the success criteria can lead the project team to work in opposite directions that might be harmful to the company. Furthermore, in order for a success measurement system to work, the understanding of what is measured and how important it is, should be the same for all the stakeholders within the company [Davila et al. 2005]. Hence understanding the relationship between success factors and success criteria is critical. Research activities tend to concentrate on one or the other dimension of success, where in this paper we investigate the relationships between the success factors and how they influence/interact with the success criteria in an NPD context. Put more specifically, underlying the relationships between the attribute of project managers (success factors) and the success criteria in NPD. We will try to provide recommendations to answer the following research questions:

- How do project managers perceive the importance of success criteria in NPD activities? What are the characteristics of the managers that influence their differing perceptions of the importance of the NPD success criteria?
- Our recommendations are derived from the survey responses of 16 product managers from different functional orientations of a company and looked through their attributes and roles such as management level, experience, age, geographical situation, etc. Prior to the survey 10 interviews were carried out to assess and complement the list of success criteria.

2. Research scope

In this section we will define the research scope of this paper both in terms of success criteria and success factors and a description of the company case.

2.1 Success criteria

Measuring success of NPD processes has always attracted the attention of academics and industrials and many lists can be found in literature and are reported in the review presented in [Ernst 2002]. From the perspective of profit, five specific criteria are generally used to assess the performance of product development effort, namely: product quality, product cost, development time, development cost, and development ability [Ulrich and Eppinger 2008]. These criteria focus mainly on the product, both technically and economically, discarding the importance of behavioural and organizational aspects related to the product. Griffin and Page [1993] put together an extensive list of NPD success criteria, where 75 success/failure metrics where reported [Griffin and Page 1993], and they classified them in three dimensions namely: Customer acceptance, Financial performance and Product-level metrics. However this is too large of a list to be used in this study, as the managers would not find the time to either participate or answer correctly. Furthermore, several of these metrics presented where reported to be very similar in nature [Kazerouni et al. 2011] which would confuse the surveyed managers. Aaron, J.S. *et al.* put forward a shorter list of eighteen criteria of project success based on an analysis of a large and detailed database ranging over several technological projects, they were later on classified into four success perspectives in terms of pre-completion of the project, short term, medium-term, and long-term goals [Aaron et al. 1996]. These 18 success criteria are the ones considered in this research and are listed in Table 1 with an additional two criteria (*bold italics*).

Table 1. Success criteria and their success dimensions

Success Perspectives	Measurable Success Criteria
Internal Project Objectives (Pre-completion)	1. The project team meets the schedule objectives 2. ***The project team succeeds in reducing product complexity*** 3. ***The project team expresses the overall satisfaction*** 4. The project team meets its budget objectives 5. The project team successfully manages other resource constraints
Benefit to Customer (Short term)	1. The new product meets its functional performance. 2. The new product meets its technical specifications and standards 3. The new product fulfils customers' needs 4. The customer expresses satisfaction about the new product 5. The new product solves customers' problems 6. The new product has a favourable impact on the customer 7. The customer is actually using the new product
Direct Contribution (Medium Term)	1. The new product has created or is expected to create a larger market share 2. The new product has generated immediate revenues and profits 3. The new product has become an immediate business and/or commercial success
Future Opportunity (Long term)	1. The new product will help creating new opportunities for the future 2. The new product (project) will contribute to the capabilities or competences of the company 3. The new product will contribute into aligning the company with its vision 4. The new product will create a new market or other new potential products 5. The new product (project) will assist in developing a new technology

A valid question that can be asked at this stage is whether these success criteria are complete and relevant in the context of the organization used here as a case study? In order to answer this, a set of ten interviews with managers from China (3), China and USA (5) and Denmark (2) were carried out to

validate it and explore possible extra criteria to add to the list. The managers went through the list and discussed the different criteria and tried to add to them when needed.
The outcome was unanimous agreement of their relevance; two extra criteria (one tangible and one intangible) came forward belonging to the pre-completion perspective highlighted in bolded italics inTable 1. This brings the total number of criteria to assess to twenty which respects the 15-20 range proposed as a balanced scoreboard in [Davila et al. 2005].

2.2 Success factors

As stated above, success factors are the facts and situations that influence the outcome of the NPD process success, and ultimately to overall successful NPD activities. In this paper we will use the frame proposed by the research presented in [Cooke-Davies 2002]. Cooke-Davies [2002] proposes 5 main factors and his findings are based on a detailed analysis of 136 (mainly) European projects that were executed between 1994 and 2000 by a total of 23 organizations. The five proposed factors and how they will be used in the context of this study are as follows:

1. The project managers: this will be the main focus of this study where the surveyed stakeholders are all managers at different levels within the case company.
2. The project team: this will only be partially addressed as one of the success criteria.
3. The project itself: we are using a single case study approach where this dimension is not investigated as the case company doesn't run a very diversified portfolio and is very specialized, which makes this dimension of lower relevance to the work presented here.
4. The organisation: this will be indirectly addressed through the geographical location of the managers and their functional affiliation.
5. The external Environment: this will only be indirectly addressed through the geographical location of the managers.

To summarise, we will mainly consider the factor of the project managers and their attributes in order to draw a clear picture of the relationships between their characteristics and their perception of project success criteria in NPD activities, as well as trying to understand the reasons for the agreements and disagreements among them.

3. Research objectives

In this research, the influence of project managers' attributes on measuring/perceiving NPD success through the pre-completion, short term, medium term and long term views are investigated. The investigated attributes of the NPD managers are namely: Function, Geographical situation, Management Level, Years of Experience in PD (in the company and at the actual position), and Age, these are illustrated in Figure 1. It is worth noting that because of the limitation in length; only the first three attributes related to the organisational structure are discussed.

4. Research methodology

The basis of this research was an empirical investigation among 26 managers of NPD from one company.

4.1 Sample of managers

The project is carried out in a large Chinese owned company of about 1000 employees (including subsidiaries). The company deals with technologically orientated projects, as it is a worldwide provider and manufacturer of sensor technology.
The population of managers collected for this study belongs to several departments very close to NPD, namely: Marketing, Technology Research, Product Design, and Manufacturing. These departments are distributed in the USA (100 employees), Denmark (22 employees), and China (500 employees). The company has it's headquarter situated in the U. S; and the R&D centre and manufacturing are based in China, whereas the branch situated in Denmark is specialised in sales and the market hub in Europe.
In total there are 30 managers who were identified as relevant to this research. Ten of these managers already participated in the preliminary study aimed at validating the success criteria. The remaining 20 were contacted of which 16 participated in the research.

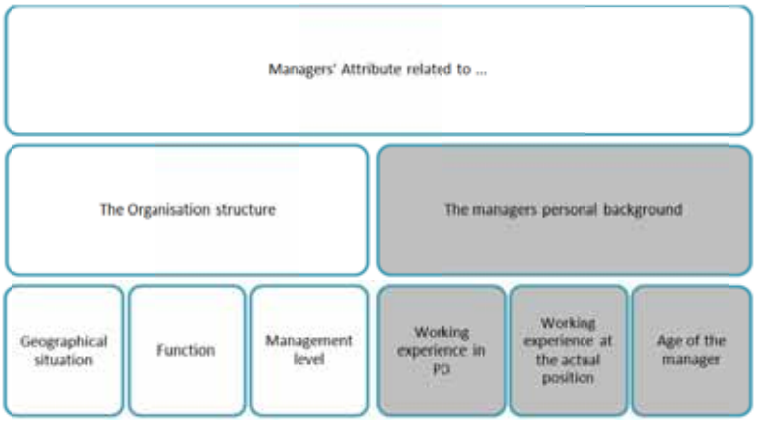

Figure 1. Classification of manager's attributes

4.2 Data collection

Information was collected through an online survey. The survey was developed based on the complete success criteria listed in Table 1. First the managers were asked to fill in their personal background information; this included geographical situation, function, job title, working experience, job experience, age, and gender. For the possible further investigations, they were also asked if they were willing to participate in further interviews/surveys, of which 6 agreed.
The online survey presented the different categories of success criteria and respondents were asked to assess the importance of the different criteria in assuring the success of a new product on the market. For each question, the respondents needed to assess the level of their agreement using a 5 points likert scale ranging from 1 (Very Low Importance) to 5 (Very High Importance). They also had the option to select zero for "I don't know" or N/A. An additional comments field was also provided.

5. Analysis and discussions of the results

This section presents the analysis of the data gathered from the survey. The empirical investigation illustrates the confirmation by the managers of the importance of the list of success criteria presented to them. Moreover, the analysis also shows that there exist some differences in how managers perceive these criteria.

5.1 General overview of the analysis

The common perception and understanding of the importance of the project success criteria in a company is vital for channelling the work efforts towards one common goal which is launching successful products on the market. However, different managers might have different views of what is important. For instance, managers from product design play a leading role in the stage of pre-completion where they are asked to meet the schedule as the first priority; to some extent they might pay less attention to controlling the product complexity. For manufacturing, too much complexity will bring troubles into the process control leading to cost increase which could influence the sales and the net profit.
The 16 survey responses were analyzed through the averages of the Lickert scale ratings corresponding to different project implementation stages.
It is worth noting that in Figures 2,3,4,5,8,9 and 10 the lines linking the data points are there to improve the visualisation of the figures and do not mean that data is continuous.
In the stage of pre-completion, the criteria focus on measuring the project effectiveness. As seen in Figure 2, the criterion "the project team meets the schedule objectives" is regarded as very important to measure the project success with the lowest standard deviation (0.89), which means better agreement between the managers. Conversely, the criterion of "The overall satisfaction of the project team" has the lowest importance rating with the highest standard deviation (2.21). It is also interesting to note that the criterion with the lowest rating was the only intangible one of the five, which might explain the higher variations in the ratings.

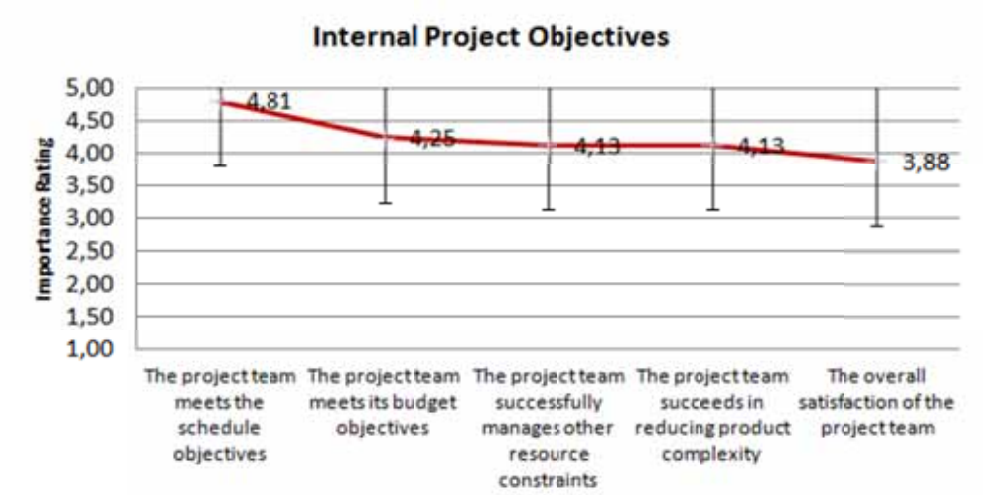

Figure 2. Importance rating with standard deviation in pre-completion of a project

In the short-term perspective, the criteria to measure the project success emphasize the product performance and customers' requests. Among these criteria, two are used to measure the product's performances and the rest are the measurement from the customer side. As one can see in Figure 3, except for the criterion "The customer is actually using the new product", all criteria were rated between 4.13 and 5. Where all sixteen managers were unanimous in awarding 5 (very important) to the criterion of the new product needing to meet its functional performance. "The customer is actually using the new product" criterion got the lowest rating (3.44) (close to moderate importance), with the largest standard deviation value (2.50). The company's products are used to detect and monitor the environmental safety so technical functions are extremely important compared to other characteristics. As for the divergence of opinions regarding the customer using the new product, the explanation could be found in a quote from one of the interviews: "*This is a very special industry where the end users usually work in a refinery or oil field and are difficult to get in touch with*". The information regarding the customer's request is only gathered from the company's service centre and sales, and sometimes even distributors. This shows somehow a disconnection between the managers of NPD and the end user which is much needed to align needs.

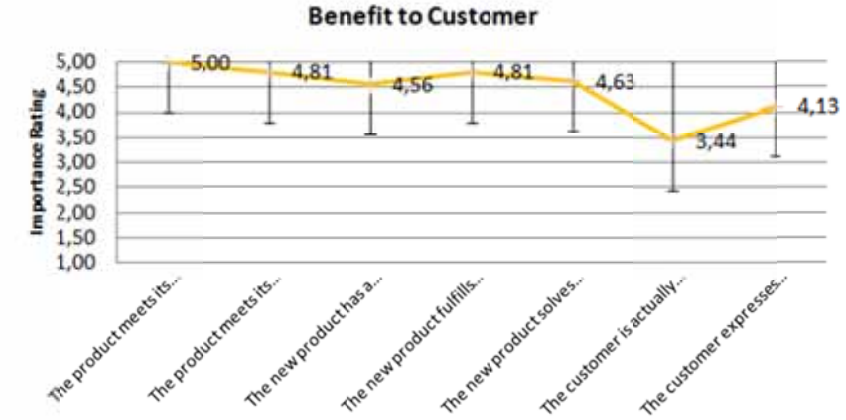

Figure 3. Importance rating with Stdv in the short-term perspective of a project

Figure 4 illustrates a fairly even trend to show that the success criteria at the stage of medium term are perceived as equally important. It indicates little individual differences in the perception of the importance of the direct contributions, however these criteria are also all financial and tangibles which managers generally tend to concentrate on and know well. It is also common in large companies to concentrate on money-based metrics or ones easily converted into money [Amram and Nalin 1999].
The criteria belonging to the long-term perspective, concern the possibility for the new product to offer an opportunity to the company's future growth. As illustrated in Figure 5, "The new product or

project will assist in developing a new technology" got the lowest rating (3.8) in comparison to other criteria. The two largest standard deviation values 1.90 and 1.86 are assigned respectively to "the new product contributes into aligning the company with its vision" and "The new products helps developing the capabilities or competences of the company". Again, these criteria are intangible which creates more confusion among the managers and hence the largest disagreement on the perception of their importance. Such differences will be analyzed by the chi-square analysis in the next section.

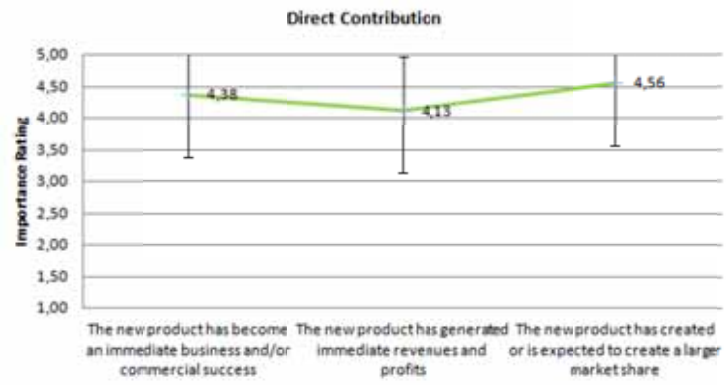

Figure 4. Rating with standard deviation in medium term of a project

5.2 Analysis based on the attributes of the managers

The previous sections presented the different general trends for the perceptions of success criteria among managers throughout the different dimensions of NPD. The following analysis looks into the significance of the differences, thereby leading to the further discussion of how they impact the NPD projects success. Each manager when rating the importance of the success criteria will do so according to two main perspectives: the first is his/her own personal background and the second one being the characteristics that relate him/ her to the organizational structure (Figure 1), only the latter is reported in this paper.

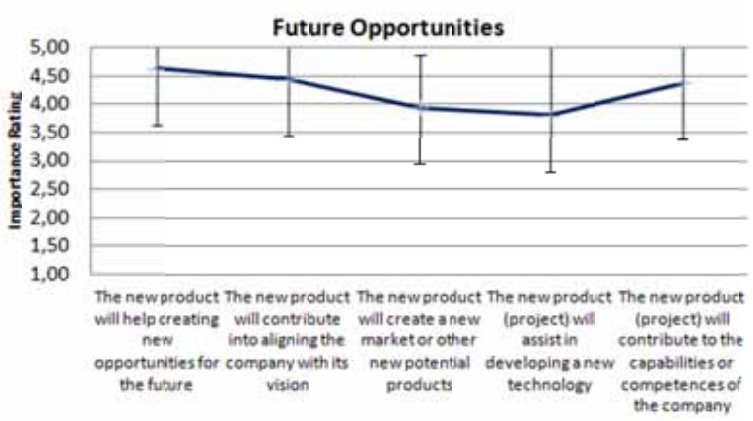

Figure 5. Importance rating with standard deviation in long term of a project

The first category would be the function of the managers, i.e. to which functional department they belong. Such functional units formed in contemporary business firms reflect a relatively autonomous and interactive relationship between departments that effect the NPD process [Ulrich and Eppinger 2008] and hence the importance to include them in the analysis. Secondly, the geographic situation to which the managers are affiliated might affect their perception of the success criteria, as it is expected that the different working cultures where the business evolves would impact on the perception of project success. Thirdly, the managers' management level means that they take upon different responsibilities and tasks; hence the difference in management level within the organization is expected to influence the perception of the success criteria.

To start with, the sixteen respondents are clustered from the organizational perspectives as shown in Figure 6. This figure also shows that some managers work at two places at the same time (US- China, US-Denmark). Working at more than one place is generally common in global companies of which the headquarter may be located in a specific geographic region but with a management team moving across the globe jointly making major decisions in NPD activities [Ulrich and Eppinger 2008].

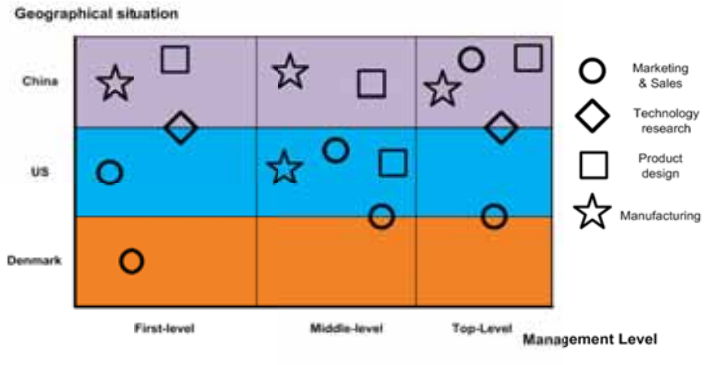

Figure 6. Clustering of the managers versus country/management level and function

In the following sections, the different perceptions of success criteria linking the mangers' attributes to their differences in perceiving the importance of success criteria will be explored and discussed. The Chi-square statistic (0.05 level of significance) is used to compare the discrepancies of the perception of success criteria between the independent categories, where the general hypothesis is that there is no significant difference in the perception of success criteria of NPD between the different managers.

5.3 Impact of the function of the managers

The category of function is classified into four variables as seen in Figure 7a . These four functions are closely related to [Ulrich and Eppinger 2008] general product development activities.

Figure 7. Distribution of the managers per attributes

The null hypothesis tested here reads as follows: *Ho: The function to which the managers belong to have no significant influence on how they perceive the importance of the success criteria of NPD in every stage of a project execution.*

The calculation of the chi-square statistic presents that all the chi-square values are less than the correspondent critical values leading to the null hypothesis to be accepted for each criterion. It indicates that there is no significant difference between the four functions in perceiving the importance of these criteria to measure a project success. This is a surprising result as one would expect the functions being managed differently and having different focuses in short, medium and long term, would influence how the managers perceive the importance of success criteria. This is good news for the company and may be due to involvement of people from different functions early on in product concept phase helping all the functions to align their goals.

5.4 Impact of geographical location of the managers

The distribution of the managers by location is illustrated in Figure 7b. One could notice that the branch in Denmark is much smaller than the other two, which is also the case in the overall distribution of employees. The following null hypothesis is evaluated: *Ho: The geographical situation*

of the managers has no significant influence on how they perceive the importance of the success criteria of NPD in every stage of the project execution.

The chi-square analysis (values of 11.1 and 13.819; critical value 9.488) showed that there are two criteria for which geographical location has significant influence on managers' perception of the importance of success criteria, the two criteria are: 1) the project team successfully manages other resource constraints, and 2) The new product will assist in developing a new technology. It means that the null hypothesis is (partially) rejected.

Figure 8 shows the trend of how managers from the three countries perceive "*the project team successfully manages other resource constraints*". Managers in Denmark rated this criterion as of moderate importance, managers from China regarded it as important even very important; while the US managers are spread from moderate importance to very important. Figure 9 illustrates that the perceived importance of the second criteria "The new product will assist in developing a new technology" is perceived diversely. Managers from China think it is important to very important; managers from Denmark perceive it as moderate, and US managers thought the importance of this criterion varies from less important to mainly important.

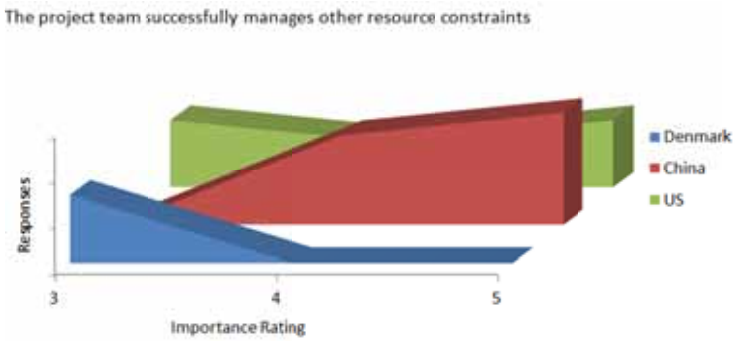

Figure 8. Discrepancy in the perception of success criteria (1)

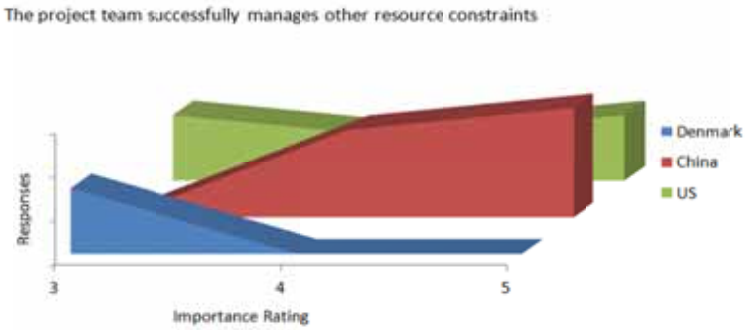

Figure 9. Discrepancy in the perception of success criteria (2)

The interesting result comes from the Danish managers who belong to the marketing/sales. One of the main functions of marketing is to analyze the market and customers' needs; this can explain why the Danes thought that managing other resources constrains, which might occur when the product development activities already started was of medium importance, same goes for developing a new technology which is often out the scope of marketing. In addition, the interview information can shed light on such discrepancy as one manager from Denmark expressed "*Original detailed design specifications and requirements are fundamentally more critical than resource allocation"*. In other terms they focus on the product itself rather than the project.

5.5 Impact of management level of the managers

The levels of management are classified basically into three categories: first-level, middle –level, and top-level, each of which performs different function in the company. Top-level managers are ultimately responsible for the organization's development instead of directing the daily routine activities. Middle-level managers work for both sides, an upward communicator to offer and suggest

views and improvements to the top management; on the other hand, motivate and assist the first-level managers to achieve business objectives. The first-level managers are responsible for the everyday management of line employees who actually make the products [Davila et al. 2005]. The tested null hypothesis reads as follows:
Ho: The management level of the managers has no significant influence on how managers perceive the importance of success criteria of NPD in every stage of the project execution.
The results of the chi-square test show that the null hypothesis is rejected for only one criterion: 1) The new product will contribute to aligning the company with its vision (10.099 with the critical value 9.488). Figure 10 shows the trend of the different perceptions of the importance of this criterion. All of the top managers regard this criterion as very important, while the middle-level managers rate this criterion as important, and the first-level managers had split opinions as some perceived it as moderately important and the others very important.

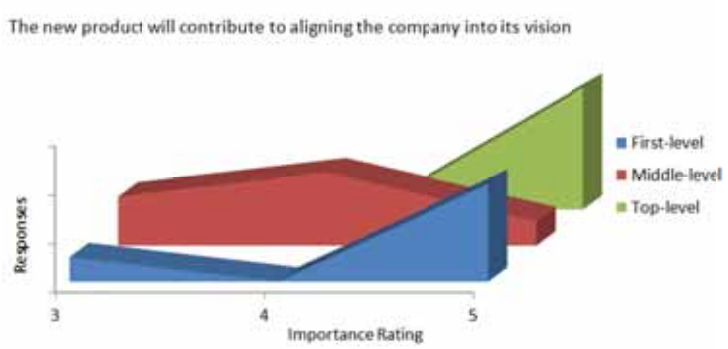

Figure 10. Discrepancy in the perception of the vision success criteria

While the differences are not that large, vision remains a very important issue as this is supposed to be a dimension that all managers should agree upon as it is the company's stepping stone to the business model which they create value with. To better understand this discrepancy, three interviews with three managers from the three management levels were carried out. The top manager did not explain the result but pointed out the importance of making sure this should be looked at "*it gives us some indication where we should put our effort in order to improve our product development activity".*
The first-level manager explained by the proximity rule, as vision by nature is defined by the top management hence it is of lower importance for lower management *"It seems logical to me that top management is more in favour of aligning to visions than lower management. Vision is a typically top management issue, and lower employees might not even know that the company has a vision. This does not say that a vision is not important, only that top management focus on it."* However, while vision is a top Management issue it still should be communicated through to the rest of the company at all management levels [Davila et al. 2005].
Finally the middle manager (the link between the two managerial levels of top and first levels) stated the following "*Vision is very important to ignite peoples' passions and increase creativity in product development… But with the company's expansion, the project is the focus and not the people … correspondently engineers and lower managers are busy with the project delivery without any consideration of alignment of the vision",* this is in line with what was reported for both the top and first level managers. It is an interesting finding that the expansion of the company is used as a reason for the loss of the vision throughout the organisation.

6. Conclusion

The research presented here sheds light on the nature of measuring success in new product development at a company level while considering both success criteria and success factors.
A set of success criteria taken from the literature has been identified and evaluated, additional criteria were added and they were more related to the specificity of the company as a technology developer.

The criteria were analysed in regard to their perceived importance in New Product Development success from managers with different company roles. In general, they have been perceived by managers as important measurements in new product development activities.
The findings show that success factors related to managers have all to a certain extent a significant influence on how success criteria are perceived at company level. The bigger disparities tended to be on the criteria that were more intangible, such as the vision, this is quite an important point as the intangible success criteria are reported in literature as being both critical in success measurement and hard to asses, while having a large influence on the output of the NPD process of companies, while the tangible ones have been, traditionally, already in the success measurement systems of companies for decades. Furthermore, these results also means that the background of the managers (success factors) will influence the perception of a success criteria scoreboard which contrasts with its very objective "raison d'être".
In the prospect of having a balanced scoreboard for an effectives success measurement system, the importance of success criteria should be seen similarly across the company's management team, if they are to fulfil their roles of monitoring success, learning from success and help the communication between the top management and the organisation.
"What gets measured gets done", "what has to be measured becomes crucial", as one doesn't want the company's NPD activities to be aligned to an ill defined measurement system.
However, it is important to state that this research is limited to results obtained from one single company and only from the NPD managers; it could be interesting to compare results if we compared the viewpoints from engineers of the core design team to the ones from the managers, as design engineers are the ones taking decisions on the daily basis when it comes to developing new products.

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