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A Conceptual Model of the Success Assessment Indicators and Critical Impact Factors for the New Product Development

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Abstract

Stages of new product development (NPD) process have mainly been divided into fuzzy front end phase and project execution phase in most research. The main purpose of this paper is to investigate the critical impact factors of each phase in a NPD process and provide the success assessment indicators after the project is completed. The indicators to measure the degree of success for a specific NPD project are further categorized based on the literature and business practices. This research contributes an integrated perspective for assessing the successful cause and degree of a NPD project. Field data is collected in order to verify the validity of the overall framework developed in this work.

Keywords
Project management, new product development (NPD), critical impact factor, success assessment indicator

1. Introduction
During the speedy change of industrial environments, market competition requires firms to obtain and apply resources to offer products with better qualities in a timely manner and with continuously improving efficiency, which could create value and sustain competitive advantage [1]. Therefore, New Product Development (NPD) is an important resource of competitive advantage and organizational renew in the company. Although NPD is a critical activity in the firms toward innovation and escalating competitiveness, but the high failure rate, high cost and the increasing risk on the techniques and commerce in NPD which was treated as a high risky activity [2]. To discover why continuing NPD comes with high failure, many researches are analyzing critical impact factors on success of NPD [3, 4].
If managers could control these critical impact factors, and optimize them, managers could escalate the predictability and achievement in every process of NPD. Though understanding the critical impact factors can raise the efficiency and fit the expected milestone of the NPD project, the new product might not gain overwhelming success on the market. While new products sales are successful on the market which represents the NPD project is genuine successful, not just complete the project execution. Time to market, quality of products and costs have direct and important connections with success of the NPD projects [5, 6, 7]. Hence, success of the new product on the market is still related to the efficiency of project execution. But we need some measurable indicators to completely assess the success degree of the NPD project on the managerial aspect, valuable aspect and technological aspect.
The past literatures mentioned less about a whole perspective on discussing the critical impact factors and relevance of the NPD in each phase, and combine performance indicators of the NPD project to thorough assessment the successful cause and degree of a project (including initiation, executing, and after completing the project.) For the reason, to recover the gap in the research domain, this study is developed. It can be fully realized the effectiveness and efficiency of the NPD project and critical impact factors on NPD which affects success degree of the whole project.

2. Overview of Literature Perspectives
In this section, the process model of the NPD project will be discussed. In addition, the critical impact factors of project that has been identified in prior studies are investigated. Finally, the paper examines the relevant theoretical perspective about the developed assessed indicators for measuring the degree of success in the project.

2.1 The Process Model of New Product Development Project
The process model of NPD project can be mainly divided into fuzzy front end and project execution. The fuzzy front end stage is the first stage of NPD, which contains ideas emerging, ideas evaluation, decreasing the uncertainty of market and techniques, and project planning [8]. A lot of researches mentioned the importance of fuzzy front end in

successful projects [9, 10, 11]. And fuzzy front end will determine which type of project being executed. Scholars also remark how fuzzy front end affects the sequel project execution phases, which leads to success of the project indirectly [8, 10]. Hence, it is the primary target to look into deeply the impact factors of fuzzy front end and its influence on sequel processes of the NPD project and success of the project. The project execution stages include the processes of practical project implementation to the end. The efficiency of the project execution will have impact on success of the project. During executing the project, there must be expected and unexpected problems. Enterprises are looking forward to diminishing lead time of NPD and raising the efficiency of cost benefit, which will determine if they can discover problems at early stage and solve problems [12]. Accordingly, the related impact factors should be discussed how to find and solve problems and execute effectively at project execution phase.

After the NPD project was finished, companies will release the new products to the market. The sales of new products on the market can determine whether the whole NPD project actual succeeded or not [5, 13]. Thus, the research provides another stage, project achievement, which is being applied the indicators in evaluating every aspect of project and confirming the degree of success.

2.2 The Critical Impact Factors of New Product Development Project

First, recently, the competitive capability of NPD is associated with quality, cost and time to market which attracted researchers' great attention. And managers are interested in optimizing cost, quality and lead time [5, 14]. In order to improve the benefit of the NPD project, enterprises must develop toward three targets of speed, cost and product quality, and balance effect among them. Which kind of priority orders in resource arrangement and importance on competitive capability depends on the target or demands of the project in enterprises.

Second, the NPD project will be involved with team members. Prior studies reveal that a higher level of related employees' contribution could lead to better product development performance [1]. However, team members need to face nervous situations all the time, because the NPD is full of process complexity and uncertainty of techniques and commercialization [14]. For instance, when the project team made dramatic scientific breakthrough, the technical uncertainty might increase. But if when the project team confirmed the company lacked of competence in achieving their design into production or into the market, the commercial uncertainty increases (e.g., there is no experience in producing or selling these type of products) [15].And further, the project team must adapt environmental changes or changes from the demands of customers, and encounter different types of uncertain factors and conflicts. Thus, team members are individual and group in stress [6]. Some scholars pointed out that the stress didn't affect the work performance, but the determinant intervention of stress management affects performance [16].

Third, besides, the NPD is knowledge intensive activity must include all suitable employees to create fruitful products by linking upstream and downstream activities [1].Whether team members and managers are capable of finishing project with related knowledge and competence is the critical factor. To summarize many scholars present the impact factors of NPD project performance include: project factors, organization factors and conditional factors. And the scholars emphasize on combined impacts on the result of project execution [6].

2.3 The Developed Evaluation Indicators for Measuring the Successful Degree of Project

A successful NPD project must be able to contribute technical knowledge to escalate this product and future research development [8], and produce final product which earns its expected market share on initial schedule. And a successful project must be kept in time and budget [1, 7, 14]. It should be multi-aspects in NPD project performances, and successful criteria should be comprehensive enough to reflect various views. It is common to distinguish for assessing the success degree of the project between internal measures of success, such as in budget, schedule, and performance goals, and external measures of success such as the value of the project and customer satisfaction [17].

Consequently, this research suggests assessment of the NPD project includes three indicators: First, a managerial indicator, applied in assessing managerial performance on project, includes time (whether done on schedule deadline), cost (whether met budget cost); Second, a technical indicator, applied in assessing technical performance on project, includes product quality (whether fit expected standard), technical satisfaction (whether contained technical value, innovation and followed expected technical planning); Third, a valuable indicator, applied in sales performance after products released on the market, includes sales condition (whether achieved expected sales volumes), customer satisfaction (whether customers feedback conformed anticipated appraisal).

3. Theoretical Framework Development

This study segments process of the NPD project in three stages: 1. fuzzy front end; 2. project execution; 3. project achievement. As shown in figure 1, there are different critical impact factors on different stages. The theoretical framework describes that impact factors on fuzzy front end are conditional factors and organizational factors; in project execution are project characteristic factors and project participator factors. The status of these impact factors is

inclined to different problems and situations in each stage. Managers could assist the NPD team to forecast the possibility of project development if taking control of these impact factors. The developed situation and decision in fuzzy front end has direct influence on the methods and direction being executed in project execution phase. And the efficiency in project execution, of course, has direct compact on success of project achievement. The decisions (e.g., design, material, function etc.) of related products in fuzzy front end also made indirect impact on the measuring indicators' evaluation in project achievement. Accordingly, the whole NPD is the linking process.

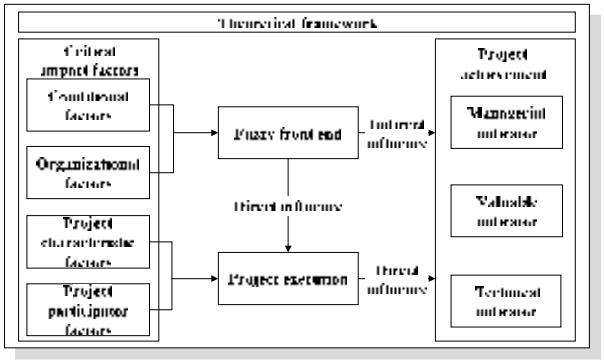

Figure 1: Theoretical framework of NPD project

4. Conceptual Model and Hypotheses

4.1 The Conceptual Model

The proposed conceptual model is presented in figure 2, the symbol '+' represents positively affect, the symbol '–' represents negatively affect, and the direction of arrows represents impact of the prior factor to later factor. In conceptual model, every impact factor includes several sub-factors. The analysis of these sub-factors will assist us to understand more clearly the critical factors in each impact aspect of the project in different stages. We will develop the hypotheses through the description of conceptual model for building following research base.

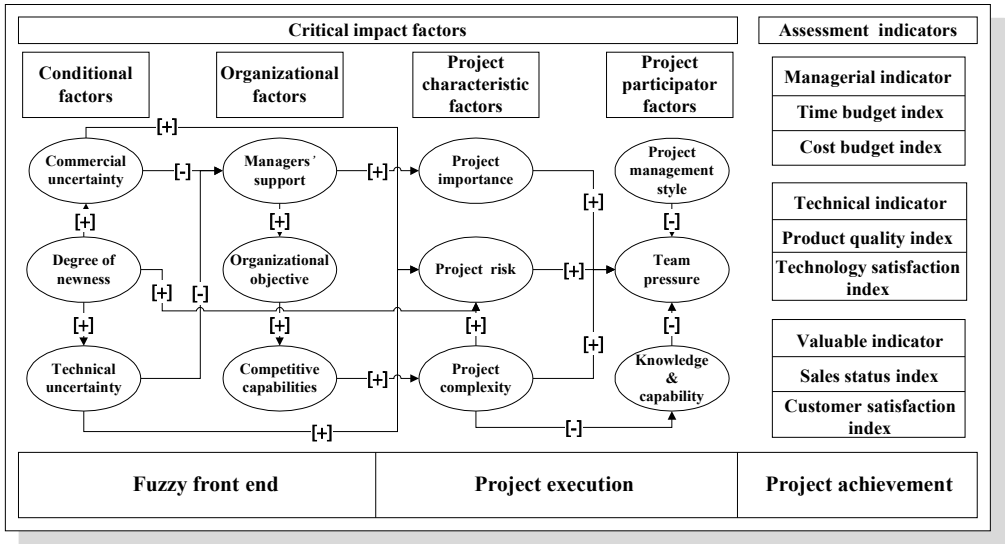

Figure 2: Conceptual model of NPD project

4.2 The Hypotheses

The conditional factors of the critical impact factor of NPD in fuzzy front end include degree of newness, commercial uncertainty, and technical uncertainty. A NPD project gets ideas of higher level innovation at fuzzy front end stage, which means the team lacks of similar experience in this field in the past. The possibility increases higher that this

team might need new technical breakthrough and support. It will raise the uncertainty of techniques. Besides, it might represent absence of the products or application on the market if the level of innovation is higher. Therefore, it is difficult for enterprises to predict sales and market acceptance, which raises more commercial uncertainty [11].

Hypothesis 1. *A higher degree of newness leads to positive impact on more increase in technical uncertainty during the fuzzy front end.*

Hypothesis 2. *A higher degree of newness leads to positive impact on more increase in commercial uncertainty during the fuzzy front end.*

The organizational factors in fuzzy front end include managers' support. Supports from managers are quite important whether the project could be proceeding smoothly [4]. If senior managers in enterprise could give highly support to the project, then the project could move into execution. In the meantime, team members show higher determination and morale when the project is proceeded. If managers show no support from the initiation of the project, the project tends to be end in fuzzy front end [9]. However, the degree of support from managers relies mainly on realistic value, for example, possible future sales or market acceptance. When commercial uncertainty of this project is raised higher on future market, the attitude of managers usually turns conservatively and managers will show less support. And if the technical uncertainty of this project is higher, that is the decreasing possibility of the product into production, managers would hold and suspect if they want to invest great amounts of resources on this project, which they will turn less degree of support.

Hypothesis 3. *Managers' support is negatively affected on a higher commercial uncertainty during the fuzzy front end.*

Hypothesis 4. *Managers' support is negatively affected on a higher technical uncertainty during the fuzzy front end.*

The organizational factors also include organizational objective and competitive capabilities. The organizational objective is decided by the decisions from senior managers and the vision and characteristics of organizations [9]. And organizational objective affects what is the goal of the project. In order to accomplish the goal of the project, it will affect the important priority sequence of competitive capabilities, such as the main and sub sequence of quality, time to market or cost. Hence, senior managers must provide NPD team great amount of supports and define explicit relative importance of competitive capability on the specific NPD project [5].

Hypothesis 5. *The aim of managers' support positively affects* o*rganizational objective during the fuzzy front end.*

Hypothesis 6. O*rganizational objective positively affects the importance sequence of competitive capabilities during the fuzzy front end.*

In project execution phase, project characteristic factors include project importance, project risk, and project complexity. The importance of a project in the firm will affect how many resources gained. More important of the project, more required resources. Of course, the degree of managers' support decides the importance of the project. With full support from managers, the project will be treated as prior mission to be done. Any support from enterprise in the project can be required easily. If not, the project may terminate under limitation and the resource shortage [4].

Hypothesis 7. *Managers' support positively affects project importance during the project execution phase.*

For project risk, the risk in project execution phase usually exists after the new product develop concept and idea being decided in fuzzy front end till the project is being executed, it is easy to derive deviations from specifications. Five conditions in the deviations of factors from specifications include changes in target market, technical methods, project objectives, project responsibilities, and deviations from planned schedules. It may be necessary to adapt changes to requirements like changing customer demands or technical advances in a dynamic environment [11]. If deviations from specifications exist, it will affect efficiency of the project execution and the correct direction. When with higher degree of newness in fuzzy front end, it might cause higher commercial uncertainty or technical uncertainty. If with higher commercial uncertainty and technical uncertainty, it is easily to cause deviations from specifications [11]. Thus, the project in degree of newness could affect deviations from specifications, which bring risks in project execution.

Hypothesis 8. *A higher degree of newness positively affects project risk during the project execution phase.*

Hypothesis 9. *A higher commercial uncertainty positively affects project risk during the project execution phase.*

Hypothesis 10. *A higher technical uncertainty positively affects project risk during the project execution phase.*

The factor of the project complexity will also affect the efficiency of the project execution. If the NPD project is quite large involved with each resource from the cooperation of cross divisions and cross industries, then complication of the project is quite higher. If the project is the improvement of existing products executed by initial development team, then the project might be less complicated [1]. Moreover, it is very difficult for the mangers to use the limited

resources and to achieve the minimum of cost, short lead time and product quality maximization at the same time. In this way, different backgrounds in different firms and project targets in the NPD project will create different priority orders of the competitive capability [5]. If the enterprises are seeking the achievement of several competitive capabilities simultaneously, such as taking quality and cost into consideration at the same time, or quality and time to market, the project is probably higher complicated under execution and control. Of course, with higher project complexity comes with the possible formation of deviations from specifications which increase the risk of the project.

Hypothesis 11. *The demands of competitive capabilities positively affect project complexity during the project execution phase.*

Hypothesis 12. *Project complexity positively affects project risk during the project execution phase.*

Another critical impact factor is the project participator factor during project execution phase. The project participator factors include project management style, team pressure and knowledge & capability. The cause of team stress might multi-dimensional. First, team members need to face nervous situations all the time. If managers provide management intervention and supporting, it will decrease the negative impact from stress on work performance. Then transform pressure as strategic tools into improving achievements of the projects in the company. Hence, the management styles of the project leaders have determinant impact on success or failure of the project [6]. Management style means under different complicated and uncertain backgrounds, managers improve specific individual or team activities on the base of thinking and behaving performances [15]. Different organizational characteristics and managers' styles lead to different project management styles. Different management styles will affect the variation of executing project management manner. Researchers usually emphasize on the difference between emergent style and planned style [15]. The supporters of emergent style think this variable management style can improve creativity and prompt creation. But other scholars consider the disciplined planned style is the focus and improvement of the efficiency of the project. Both sides admit both theories need balance. Many researches show how two styles interact and affect with each other and explains how excellent project managers react to compete for resources for satisfying the competitive advantages, and the managers own the abilities to transfer repeatedly different management styles according to the variable situations [15, 5].

Second, effective execution in NPD project requires related knowledge and ability [18]. The team stress results from team members lacking of similar experience in this field in the past and insufficient related knowledge and ability [6]. Third, the more difficult the project in new technology, complexity, and scope, the more sensitive it is to disturbance and mismatches in the team, and the greater the demand for knowledge acquisition and development for the successful project. [18]. Therefore, if the project with high complexity leads to higher difficulty in project execution, it might increase the stress to the team. Moreover, if with high project complexity, team members need more knowledge and ability to meet the requirement of the project as the existing knowledge and ability might be hard to meet the requirement.

Fourth, with high importance of the project, though with less obstacle on project execution, team carries more anticipation and responsibilities of success causing the raising stress within the team.

Finally, milestone deadline pressures can create stress [19].With higher risk on the project might lead to the outcome of project execution not as well expected as original which increases the pressure on the team.

Hypothesis 13. *Team pressure is negatively affected by applying project management style appropriately during the project execution phase.*

Hypothesis 14. *Team pressure is negatively affected by qualified knowledge & capability during the project execution phase.*

Hypothesis 15. *Knowledge & capability are difficult to conform to project demand since they are negatively affected by a higher project complexity during the project execution phase.*

Hypothesis 16. *A higher project complexity positively affects team pressure during the project execution phase.*

Hypothesis 17. *A higher project importance positively affects team pressure during the project execution phase.*

Hypothesis 18. *A higher project risk positively affects team pressure during the project execution phase.*

5. Conclusion and Future Work

The NPD is one of the most important business activities assisting high-tech manufacturing firms to survive and earn market share. When life cycle of products is shortened, companies need to release new products continuingly and speedy. Ergo, the NPD project is more valuable for these firms and has devoted relatively more attention than others. This research will focus on high-tech manufacturing companies in Taiwan. For the research sample, 200 companies were randomly selected from high-tech firms located in the Hsinchu, Taichung, and Tainan Science Park, Taiwan. And categorize these firms based on their scales.

The above-listed the twelve factors and six measurement indexes summarized from the literature and/or exploratory interviews in a pilot study and a pre-test to provided the conceptual model and hypotheses. Furthermore, this research will investigate and examine quantitative and qualitative approaches simultaneously. Quantitative approach with questionnaires posted or e-mailed to these firms; Qualitative approach with interviewing related department managers and NPD leaders. These data collected will contribute greater insight in terms of factor analysis and examines the certainty of hypotheses. The research project is expected to be completed within a year.

The main contribution of this research is expected to help the leaders and mangers of the NPD understand the relevant impact factors and dedicate more concern to the performance improvement when in process of the NPD. Moreover, after completing the project, the research also reveals relevant assessment indicators to assist managers to progress the achievement assessment of the NPD. Therefore, it gives a complete reference framework and comprehensive perspective for proceeding and assessing the cause and degree of a successful project, or the reason of a failed project.

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