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Performance Management Guide for Research and Development Process

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***Abstract*—**Performance management seems to be essential in business area and is also an exciting topic. Despite significant and myriads of research efforts, performance management guide today as a rigorous approach is still in an immature state and metrics are often selected based on intuitive and heuristic approach. In R&D side, the difficulty to guide the proper performance management is even more increasing due to the natural characteristics of R&D such as unique or domain-specific problems. In our approach, we present R&D performance management guide considering various characteristics of R&D side: performance evaluation objectives, dimensions, metrics, and uncertainties of R&D sector.

***Keywords*—**Performance management, R&D, metrics.

I. Introduction

FOR a company to secure competitiveness, investment on research and development (R&D) area should be continued. On the other hand, as the payback period of R&D sector is long, projects are not repeatedly carried out and it is difficult to track or identify the effect, it is often excluded from objects of management. However, as volume of investment is increased and it becomes burden to a company, necessity to manage performance of R&D sector has been increased.

Especially, in order to estimate contribution of R&D sector on company competitiveness, evaluation of efficiency of input resources to R&D and effectiveness of R&D outcomes has been highlighted. However, evaluation of R&D sector is mainly carried out by applying simple financial metrics, such as ROI (Return on Investment) and ROE (Return on Equity), which are metrics of general management and production activities, not reflecting characteristics of R&D sector and strategies of organizations. Fortunately, a method is recently applied to access with multi-dimensional evaluation methods in order to reflect characteristics of R&D sector, rather than simple evolution methods, such as BSC (Balanced Scorecard), which has good effects as a strategic evaluation method [1].

However, although numerous metrics are presented in evaluation models, including the BSC, selecting proper metrics to reflect characteristics of a company and fit for the purpose of evaluation is still depending on qualitative decisions of top management of a company. Therefore, though systemized evaluation models are introduced, working metrics can not reflect characteristics of an organization. As a result, numerous metrics have been just calculated for one time use and not practically used any more.

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With these reasons, this study suggests the practical guide for R&D performance management, which is not just metric selection but the fundamental approach in a holistic way. We also consider various characteristics of R&D to suggest the most proper and applicable guide to the R&D sectors.

II. Backgrounds

A widely recognized tool, BSC, was proposed to support decision making at the strategic management level which improves the satisfaction of the strategic objectives. The key characteristic of the BSC is to maintain a balance among various managerial perspectives, as opposite to traditional approaches which mainly consider the financial data. In particular, the BSC considers four perspectives: Financial perspective, measuring the financial performance of the company, customer perspective, measuring the satisfaction of the customers' preferences, internal business process perspective, measuring internal business results against measures from financial and customer perspectives, and innovation and learning perspective, measuring the ability of the company to adapt to changes. Several companies have successfully applied BSC into R&D sectors and thereby several variants to the original proposal have been investigated [2], [3].

R&D evaluation method called TVP (Technology Value Pyramid) was also proposed and it introduced the Menu of Metrics, which comprises 5 managerial perspectives, 33 evaluation factors, and 54 actual metrics [4]. As shown in the name, TVP represents the hierarchical structure of the five managerial perspectives which describe the innovative capability of the enterprises: VC (Value Creation), PA (Portfolio Assessment), IWB (Integrated with Businesses), AVT (Asset Value of Technology), and PRD (Practice of R&D process to support innovation). PRD and AVT are the core operational foundations of the R&D enterprise, since R&D management can be characterized by efficient R&D management practices and high technology capability. On top of these, IWB and PA are related to business and technology strategy. These viewpoints reflect on how well R&D enterprise's technology strategy is linked with its business strategy, from both a corporate and a business unit perspective. VC is at the top of the pyramid, which is the principal goal of every R&D activities. TVP is accredited as an integrated evaluation model for R&D sector which is performed by the IRI Research-On-Research committee on measuring the effectiveness of R&D, and has been recently revised as Technology Value Program 2.0 that can be used as a tool to enhance the effectiveness R&D by providing a framework for selecting a small number of appropriate metrics.

To build R&D performance management system, various properties of R&D sectors should be considered as the followings. First, *purpose of performance management* like support to decision making, improvement of R&D performance, motivation, support with incentive system, organization learning, communication between departments, increase of conformity and risk management in R&D sector. Second, *level of performance management* likeefficiency, effectiveness and so on. Third, *types of metrics* likequantitative, qualitative, subjective and objective. Fourth, *target of evaluation*: researchers, departments (teams), projects and R&D functions [5]. In addition, types of researches can be classified into three levels; basic research (level 1), development of core capability (level 2) and application and commercialization projects (level 3) or development sector and research sector to differentiate evaluation methods [5], [6].

III. Components of R&D Performance Management

A. Process and Activity Schema

R&D process can be divided into several stages such as proposal, planning, execution, technology transfer and so on. Each stagealso consists of related activities. To facilitate the attainment of performance management goal, we defined the R&D activity*k*as having the parameters (T_k, S_k, O_k, R_k) and the performance metrics (E_1, E_2), which is shown in Fig. 1.

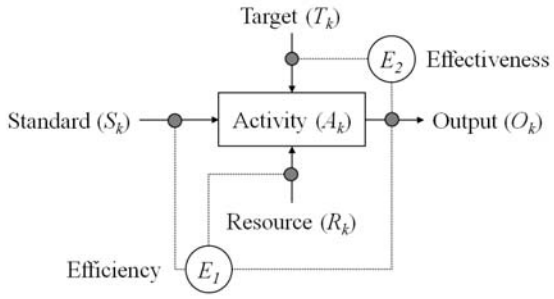


Fig. 1 activity schema and parameters

- *target(T_k): set of internal and external requirements to perform A_k.*
- *standard(S_k): benchmark to assess performance of A_k.*
- *output(O_k): set of deliverables from A_k.*
- *resource(R_k): set of resources to perform A_k.*
- *efficiency(E_1):ratio of valuable outcomes to resource R_k.*
- *effectiveness(E_2): capacity to produce an effect considering S_k.*

B. Evaluation Dimension

To identify the essential dimensions of the performance management for R&D units, this study considered three dimensions of properties as depicted in Table I, based on the literature studies and interviews with on-site specialists.

TABLE I
Evaluation Dimensions

Dimension	Types	Descriptions
R&D Project Type	Technology	Basic or Applied technology development, New business, Growth business.
	Module	Platform development applying to commercial products, advanced development for quality and component of the commercial product
	Product	New product, Major derivative product, Minor derivative product, Running change
Evaluation Time	Leading	Project selection and resource operations planning
	Current	Project Go/Drop/Re-direction, Resource operations change management
	Result	Results evaluation and rewards, Feedback to the next planning
Stakeholder	Executive	Global optimization, multi-projects decision making
	Manager	Project management, Functional management, Resource management, Skill management
	Engineer	Project practice

R&D Project Types: Based on outcomes of R&D activities, types of R&D projects are divided into 3 types; development of technology, modules and products. Each type can be classified into subcategories. R&D organization in a large company carries out all three types while one or two types of R&D can be carried out in small and medium size companies, venture companies and a government financing organizations.

Evaluation Time: It is classified into three stages according to time spectrum; leading, current and result. One of purposes of leading evaluation is to select an optimal project to be performed with restricted resources, considering profitability and ripple effects of a planned project. All evaluation metrics used for leading evaluation are calculated based on target values. In addition, target values can be made too optimistically to be selected as a certain project. In order to prevent such phenomenon, there must be a feedback system which checks performance against target values in the later and reflect results on the establishment of the next target. As an current evaluation activity to check progressing against target values, progress evaluation performs interim examination for each milestone (or stage-gate) and decides to move to the next step, adjusts target of the project or terminates the project due to changes in the market. Result evaluation compares performance with initial target or amended target values, conducts project postmortem and presents a guideline to establish the next project.

Stakeholder: The purpose of performance management is to provide necessary information in decision making process of each stakeholder which is related in R&D activities. Stakeholders can be divided into a head of the entire management level (executive), managers of project and function level (e.g. function: product planning, equipment development, circuit development, S/W development and so on)

and engineers. The purposes of top management are to effectively operate resource of a certain organization and create best results. For these purposes, objectives management and resources management should be done in multi projects level, rather than single project, managers in project level receive human resources and skill required to accomplish a project from each functional team and conduct project management to achieve objectives of a project. On the other hand, managers in function level maximize capacity of a corresponding team and aim optimal use of resources for a participating project. An engineer refers to a responsible person who generally carries out a project.

C. Evaluation Objective

Accordingly, main performance management objectives, which reflect strategies and characteristics of corresponding R&D organization, can be selected from the three performance management dimensions described in the above: R&D project type, time and stakeholder. For examples, the purpose of performance management for "research - leading - executive" is "portfolio decision making for the selection of research project" while the purpose of performance management for "product – current - manager" is "decision making for Go /No-Go/ Re-direction of commercialization project"

D. Performance Metrics

In this study, we do not pay much attention on how exactly to define appropriate metrics because it is another big topic and what we want to propose is about performance evaluation guide considering the various R&D characteristics. Instead of defining the new R&D metrics, we used the works from TVP model. More detailed descriptions and definitions of TVP metrics can be found in [4].

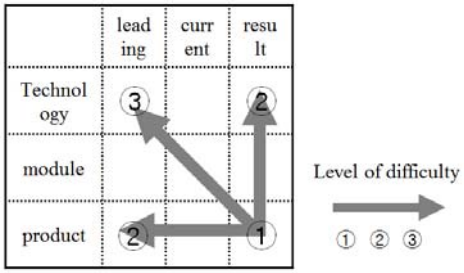
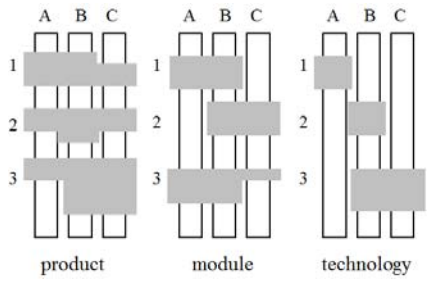


Fig. 2 performance management level



(*project 1, 2, 3 and function A, B, C*)

Fig. 3 resource allocation example

IV. Performance Management Level

Performance management is essential, but some of the things are required to evaluate the R&D process. Desired performance management level can be determined by considering performance evaluation dimensions and proper project management. Performance management level is determined according to the timing of evaluation and the project type. Since performance management level is proportional to the uncertainties of R&D sector, level of difficulty is higher for leading evaluation than result one when time spectrum is taken into account, while it is higher for technology development projects than product development projects when project type is considered. Therefore, performance management level should be decided after these have been considered as illustrated in Fig. 2.

Meanwhile, R&D projects are usually carried out by cross functional teams (CFT). As shown in the Fig. 3, the complexity of resource allocation by CFT may differ depending on what form the functional team takes when participating in the projects. In the case of product development, the project is carried out with rather various functional organizations putting resources in the project relatively equally. When it comes to technology development, in many cases, they are carried out by some functional teams involved as a unit. In addition, in the case of projects that are related to module development, the organizational form takes a medium level of complexity in between that of the project development and of the technology development projects.

We also propose a method of computing the resource allocation complexity for determining whether we should apply the project-based or functional team-based performance measurement approach.We define project compexityH_1 and team complexity H_2as in (1) and (2).

$$H_1 = -\sum_{i=1}^{n} p_i \times log_2 p_i \quad (1)$$

where$n$ is the number of functional teams and p_i is the man-month fraction of functional team i to perform the project.

$$(\sum p_i = 1).$$

$$H_2 = -\frac{1}{m}\sum_{i=1}^{m}\sum_{j=1}^{n} q_{ij} \times log_2 q_{ij} \quad (2)$$

where$m$ is the total number of employees in the functional team, n is the number of projects the functional team member i is currently participating, and q_{ij} is the man-month fraction of functional team member$i$ to perform the project$j$. ($\sum q_{ij} = 1$, for each i).

Suppose that Table II shows the example of project and team complexity. If the H_1 and H_2 is less than 1.00, the project-based and functional team-based performance managementis recommended respectively, and otherwise, corporate-level performance management is recommended instead. In this example, the project *1* and functional-team *B*, *C* should be evaluated by project-based and functional-team based

approaches respectively. However, it is hard to evaluate the project 1, 2, and functional-team *A* directly due to the complexity of resource allocation, so the corporate-level evaluation is recommended.

TABLE II
PROJECT AND TEAM COMPLEXITY EXAMPLE

q_{ij}	A		B			C		H_1
	A1	A2	B1	B2	B3	C1	C2	
1	(0.2)	(0.3)	(0.5)	(0.8)	(0.7)	(0.9)	(0.4)	1.40
2	(0.2)	(0.3)	(0.5)	(0.2)	(0.3)	(0.0)	(0.2)	1.12
3	(0.6)	(0.4)	(0.0)	(0.0)	(0.0)	(0.1)	(0.4)	0.89
H_2	1.47		0.87			0.95		-

V. GUIDELINE FOR R&D PERFORMANCE MANAGEMENT

Based on the components of R&D performance management and performance management level, the following guide should be presented.

A. Defining R&D Activity

For performance management, it is necessary to first define the standardized R&D process. When the standardized R&D process is defined, then the activity schema that composes the process must be defined. Also, the scope that defines the activity schema is determined according to the level of managing the process. For example, if the product development process is managed by stage, then the activity schema should also be defined by stage, whereas if the process is managed in the lowest level of workflow, then the appropriate activity schema will also be defined at the level of workflow.

B. Defining Activity Schema

Appropriate activity schema is defined taking into account the R&D activity and the target of performance management. Also, the parameter of the activity schema is defined before determining the candidates for evaluation metrics. However, when defining the parameter, it should not be restricted by the existing (As-Is) management level but should be described is detail as much as possible considering future (To-Be) management because such future-oriented definition can be utilized in proposing directions for improvements in R&D management.

C. Defining Performance Management Level

Subjects of performance management are selected for the defined R&D activity reflecting the strategies and characteristics of the organization. At this time, evaluation metrics are also selected for the performance management level. It is necessary to select evaluation metrics in stages according to the feasibility of performance management. When the evaluation metrics are selected, the scope for defining activity schema is determined and it becomes possible to describe the detailed purpose for performance management of applicable area considering the dimension of performance management.

D. Defining Performance Metrics

Evaluation metrics are defined using the purpose of performance management and the parameter of the activity schema. At this time, it is important to define the metrics reflecting the current performance management level so that computation and management can be done consistently. In addition, when defining the metrics, the following items should also be defined; purpose of evaluation, computation formula, method of computation, target of evaluation, evaluation period, evaluation department, and benchmarked score criteria. For metrics that are necessary for the purpose of the evaluation but cannot be computed due to performance management level restrictions, it is possible to make a case for raising the performance management level. Hence, concurrent improvement in performance management level can be expected through such a virtuous circle structure.

VI. CONCLUSION

This paper proposed a practical guide for R&D performance management. We present fundamental components of R&D performance management such as, performance evaluation objectives, dimensions, metrics, and difficulties of performance management which is proportional to the uncertainties of R&D sectors. The advantage of proposed guide is that the performance management objectives, metrics, and method can vary according to the strategies and characteristics of corresponding R&D organization.

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