

## Innovation Process from the Perspective of Measurement

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**ABSTRACT:** Innovation process is one of crucial activity in the innovation implementation of an organization. It is the heart in managing the whole process innovation management. Numerous studies have been conducted and this indirectly established reliable measurement for innovation research. In simple terms, innovation process would describe the 'how' innovation is undertaken into organization which involved the management, employees and also collaboration between organization with suppliers and customers. Some may refer it as process, activities, phases, stages, creative circle, cyclic, or technical progress. Nevertheless, it is indeed strategic and highly integrated process. Due to the complexity, researcher is required to determine suitable measurement. Previous studies have produced various measures which is independent and complex. Therefore, in order to confront with this issue, innovation process requires a balance set of innovation metrics. These metrics would assist research process turn out to be systematic. This paper has proposed two kinds of measurements: objective and subjective innovation process measures. The objectives measures establish result oriented style while subjective measures refer to the how to manage each process in innovation. Some reviews on innovation process definitions, characteristics and activities are presented so that it would be easy for management, practitioners as well as academicians to tailor with their innovation management and research objective.

**KEYWORDS:** Innovation, innovation process, measurement, output, input, objective and subjective measures.

### 1 INTRODUCTION

Innovation is everybody matters. Importance of innovation discourse leaps out from the organization mission, innovative team, value creation to customer, survival and growth, competitiveness and to the consumption of everyday gadgets ranging from products and services. Although much has been argued by scholars and practitioners, the innovation process become the heart of the success of innovation implementation. Innovation process is viewed as a sequence of activities involved in turning ideas and possibilities into reality [1]. Due to the crucial role of innovation process, organization needs to accentuate the measurement of innovation process so that the result of innovation is managed and observable. Emphasize to measure innovation is always be the priority task and is proven by most of the high achievers companies [2].

This paper reviewed the innovation process measures from the perspective of objective and subjective measurement. The following discussions will point out why we need to measure innovation process and highlighted several measures that would contribute to innovation research. Furthermore, the highlights would be beneficial points to ponder when researcher intent to embark on a study. The need to measure innovation process occur because the strategic intend of innovation itself varies across organization [3]. It is reported that organization with high growth generated from the innovation projects measured their innovation portfolio and use metric across the whole innovation process [2].

## **2 LITERATURE REVIEW**

The complexity of innovation process demand researcher to understand the details of innovation process [4]. In this context, understanding definitions of innovation process is essential since this would assist researcher to apply on whether objective or subjective measures. According to Gerybadze, Hommel [5], innovation process is describes as a phases of processes started from strategy planning, idea generation, screening, project development, market test, production, market introduction and innovation controlling. It is noted that the definition has showed the long route of innovation process. Among others, innovation process is also referred as cyclic process [6, 7] and integrate organization mechanism [8]. However, this definition is described in a more simplified view by other scholars such as [9] and [1]. These authors have identified three main stages of innovation process: generate, select and implement. As innovation process involved several stages about development in innovation activities [10], a procedure is needed to evaluate, screen the ideas, establish process from their inception to commercialization [11]. Therefore, by identified and utilized proper definition of innovation process, it might be easier for researcher to use a better measurement in their research.

In establish the working measures for innovation process, common characteristics, inter-relationship of innovation process and deliverables must be identified [4]. Gupta [4], has proposed three measures to show innovation performance at various stages: CEO Recognition of Employees for Exceptional Value Creation, Employee Ideas for Improvement and Innovation Sales for new products, services or solutions. Other measures are also included such as allocation of time in percentage for research innovation management, new idea deployment degree of differentiation, time to innovate, and rate of innovation. Besides the characteristics, the measurement for innovation process is explored through different types of innovation process generation. This has been simplified into five types of innovation process generation: technology push, need pull, coupling model, integrated model and system integration and networking model [12]. The open innovation (six generation of innovation process) is later add to this category where the internal and external of ideas and paths to market is combined for new technology development [13]. In this context, objective measurements cover the science and technology indicators such as patent while the subjective measurement cover the soft factors that related to the management such as organizational integration and user-producer relationship [12].

According to Organisation for Economic Co-operation and Development [OECD] [14], there is are enormous variation in innovation process measurement from the perspective of objectives, organization, cost, used of research and others. This is because the tendency of firm to innovate depended on technological opportunity, technological capability (labor force) and firm characteristics. Hence, three importance areas to measure innovation process are strategic, R&D and non R&D [14]. A study of how firms influence capacity to innovate and resulted performance, has proposed input indicators to measure the resources for innovation process and process indicators to reflect the innovation process management system [15]. Another approach is focused on the input, process and output measures of the innovation implementation however this only limited to objective measurements which are divided into financial, customer perspectives, resources, learning and specific service measures [9].

Due to the strategic intend of innovation itself varies across organization, innovation process is defined as ideation, evaluation, selection, development and implementation of new or improved products or services that must tie with the intended objective. These objectives include an increment numbers of new ideas, its quality, efficiency in the implementation of quality ideas as well as improvement in result achieved from the new ideas implemented [3]. From the perspective of common accounting practices, Return on Product Development Expense (RoPDE) is used to measure those intended objectives. In this context, RoPDE is derived from the percentage of gross margin (GM) from expenses that fully burdened enterprise [3].

A survey which is responded by senior executives acknowledged to measure innovation process rigorously [16]. The survey has used the 'innovation-to-cash' process which considered all efforts required from to take an idea and turn it into cash (inputs, processes and output) [16]. Other approach used to visualize the innovation activity is the funnel approach which consist of nine stages: strategic thinking, portfolio management, research, ideation, insight, targeting, innovation development, market development and sales [17]. Principally, this approach works in an organization but require extensive attention to matters inside the funnel. Although the method portrayed nine elements, the one that referred to innovation process is from the research process to the market development stage whereby each of the stages is proposed with suitable measures [17].

The characteristic of innovation process is identified as one area alongside with strategic leadership, competitive intelligence and management of technology that will determine the innovation success [18]. In this context, innovation process is viewed as the extent to which companies support the desired innovation activities. As a result, innovation process measures is established through ten areas by using the seven-point Likert type scale [18]. In a study of product innovation,

Parthasarthy and Hammond [8] has elaborated innovation process through three types of integration mechanism: functional integration, tool integration and external integration. This is because a high degree of integration and innovation input will benefit innovation frequency. Functional is an operational activities such as job design, task goals, procedures and rules of work routine. Tool integration connected the operation of design and manufacturing tools via computer. External integration link firm operation with suppliers and customers for product development activities [8]. In addressing the measure for technological innovation firm, Flor and Oltra [19] has reviewed several indicators which is based on inputs or output of the innovation process and sources of primary or secondary information. It is found that the information from manager's self assessment is useful for product and process innovation and the literature-based innovation output is best method to identify product innovator [19].

### 3 DISCUSSION

Based on the arguments from previous studies, the innovation process measurement is summarized into the following table. From the perspective of objective measurement, Table 1 indicated that most of the measures would emphasize on the physical number or output at the end of each stage These output include number of employees, ideas, products, services, solutions, projects, working time and patents occurred. In addition, measurements were also established in terms of percentage and allocation of R&D expenditure, cost, sales and training hours involved during each stages and acquisition of machinery and external knowledge. This information was prepared in numerical value, dichotomous scale and ratio scale.

*Table 1. Innovation Process – Objective Measurement*

Author/s	Innovation Process Measures
Gupta [4]	<ol style="list-style-type: none"> <li>1. CEO Recognition of Employees for Exceptional Value Creation</li> <li>2. Employee Ideas for Improvement and Innovation</li> <li>3. Sales for new products, services or solutions</li> </ol>
Chan, Musso [2]	<ol style="list-style-type: none"> <li>1. Number of idea or concepts in the pipeline</li> <li>2. R&amp;D spending as a percentage of sales</li> <li>3. Number of R&amp;D projects</li> <li>4. Number of people actively devoted to innovation</li> </ol>
Organisation for Economic Co-operation and Development [OECD] [14]	<p><b>Dichotomous scale : Yes or No</b>            During the three years (e.g: 2002-2004), did your enterprise engage in the following innovation activities:</p> <ol style="list-style-type: none"> <li>1. In-house R&amp;D – Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development)</li> <li>2. Extramural R&amp;D – Same activities as above but perform by other companies, public or private research organization of purchased by your firm.</li> <li>3. Acquisition of advanced machinery, equipment and computer hardware or software.</li> <li>4. Acquisition of other external knowledge such as purchase or licensing patent and non-patented invention and other types of knowledge from other organization.</li> <li>5. Internal and external training for personnel for new or improved products and processes.</li> <li>6. Market introduction of innovations</li> <li>7. Other preparation in implementing new product and processes.</li> </ol> <p><b>Ratio Scale</b>            Please estimate the amount of expenditure for each of the following four innovation activities in <u>2004</u> only (include personnel and related cost):</p> <ol style="list-style-type: none"> <li>1. In-house R&amp;D (include capital expenditures on building and equipment) _____ (in RM'000)</li> <li>2. Acquisition of extramural R&amp;D _____ (in RM'000)</li> <li>3. Acquisition of machinery, equipment and software (exclude expenditures on equipment for R&amp;D) _____ (in RM'000)</li> <li>4. Acquisition of other external knowledge _____ (in RM'000)</li> <li>5. Total of these four innovation expenditure categories _____ (in RM'000)</li> </ol>

Author/s	Innovation Process Measures
Carayannis and Provan [15]	<p><b>Ratio Scale</b></p> <p>Innovation Process Inputs:</p> <ol style="list-style-type: none"> <li>1. Sales of share of R&amp;D expenditure (%)</li> <li>2. Sales share of internal venture capital (%)</li> <li>3. Average training days for employees (%)</li> <li>4. Average training days for employees (%)</li> <li>5. Top management working time on Innovation (%)</li> </ol>
Malinoski and Perry [3]	<p>Return on Product Development Expenses (RoPDE)</p> $\text{RoPDE} = (\text{GM} - \text{PDE}) / \text{PDE}$ <p>Where:</p> <p>GM = gross profit by subtracting cost of sales from revenue or cost of goods sold (material, labor and overhead associated with delivering a production unit)</p> <p>PDE= include engineering, technician, product marketing and associated management labor expenses (benefits, facilities, IT, depreciation).</p>
Andrew, Haanaes [16]	<p>Input measures:</p> <ol style="list-style-type: none"> <li>1. Number of new ideas</li> <li>2. Business unit investments by type of innovation</li> <li>3. R&amp;D as a percentage of sales</li> <li>4. Full-time technical staff and how (and where) it is used</li> </ol> <p>Processes measures</p> <ol style="list-style-type: none"> <li>1. Idea to decision time</li> <li>2. Decision to launch time</li> <li>3. Project type and launch date</li> <li>4. Sum of projected net present value</li> </ol> <p>Outputs</p> <ol style="list-style-type: none"> <li>1. Patents granted</li> <li>2. Launches by business segment</li> <li>3. Percentage of sales and profit from new products</li> </ol> <p>Innovation ROI</p>
Morris [17]	<p>Research Stage:</p> <ol style="list-style-type: none"> <li>1. Number of customer groups that have been examined</li> <li>2. Application of research result in new products, services and processes</li> <li>3. Extent of participation from throughout organization in the research process</li> <li>4. Time invested in research</li> <li>5. Money invested in research</li> </ol> <p>Ideation Stage:</p> <ol style="list-style-type: none"> <li>1. Number of idea developed</li> <li>2. Number of ideas contributed by our staff</li> <li>3. Number of idea introduced</li> <li>4. Percentage of ideas from outside</li> <li>5. Number of people inside the organization who are participating in the ideation process</li> <li>6. Number of ideas collected in the idea gathering system</li> <li>7. Number of collected ideas that were developed further</li> <li>8. Number of collected ideas that were implemented</li> </ol> <p>Insight Stage:</p> <ol style="list-style-type: none"> <li>1. Unsuccessful technology and customer mash-ups attempted</li> <li>2. Successful technology and customer mash-up achieved</li> </ol> <p>Targeting Stage:</p> <ol style="list-style-type: none"> <li>1. Percent of investment in non-core innovation projects.</li> <li>2. Total funds invested in non-core innovation projects</li> <li>3. Senior management time invested in growth innovation</li> </ol>

Author/s	Innovation Process Measures
	Innovation Development Stage: <ol style="list-style-type: none"> <li>1. Prototyping speed</li> <li>2. Number of prototypes per new product</li> <li>3. Average time it takes to get from Stage 1 to Stage 5</li> <li>4. Number of patents applied for</li> <li>5. Number of patents granted</li> <li>6. Percent of ideas that are funded for development</li> <li>7. Percent of ideas that are killed</li> </ol> Market Development Stage: <ol style="list-style-type: none"> <li>1. Return on marketing investment</li> <li>2. Number of new customers added</li> <li>3. Growth rate of customer base</li> </ol>

From the perspective of subjective measurement, Table 2 indicated that measures of innovation process were established by structured questions on how each activity was performing in each stage. It is noted that the details of innovation process are reflected in terms of how the new idea is managed, how to control innovation project, employee participation and communication, how the new product developed and marketed and finally the integration between internal organization mechanisms, external (customers and suppliers) and manufacturing processes (tools and materials). One important point that could be observed from both Table 1 and Table 2 is the tendency of objective measurement to depict the result oriented style in terms of input, processes and output measures while the subjective measurement deliberated the descriptive style which elaborates each of the activity into the innovation management approach. This argument is in line with the proposed study conducted on integrated metric for innovation measurement [20]. Although it is limited to the R&D innovation, the subjective measurement for innovation process lies on the R&D Management Capability, Integration, Openness and R&D Environment. These measures are analyzed towards the impact on products and delivery to the organization.

**Table 2. Innovation Process – Subjective Measurement**

Author/s	Innovation Process Measures
Gupta [4], Carayannis and Provan [15]	Ordinal Scale – 5 point Likert Scale ranging from is always done / clearly organized to seldomly used Process oriented measures: Design of innovation management <ol style="list-style-type: none"> <li>1. Idea evaluation</li> <li>2. Concept test</li> <li>3. Profitability Analysis</li> <li>4. Innovation strategy</li> <li>5. Construction / development</li> <li>6. Ex post analysis</li> </ol> Project management and controlling <ol style="list-style-type: none"> <li>1. Project management employed</li> <li>2. Project controlling employed</li> </ol> Involvement of marketing in innovation process
Guimaraes [18]	Using 7 point Likert-type scale ranging from extremely below average to extremely above average. <ol style="list-style-type: none"> <li>1. All significant innovation must conform to company objectives</li> <li>2. All affected departments participate in the innovation process</li> <li>3. Individual employee input is important</li> <li>4. Customer input is considered important</li> <li>5. Business partners input is considered important</li> <li>6. Ability to balance risk taking with cost/benefit</li> <li>7. Clearly define measures to monitor progress</li> <li>8. Innovation objectives and progress are clearly communicated</li> <li>9. Responding quickly to required change</li> <li>10. Responding effectively to required change</li> </ol>

Author/s	Innovation Process Measures
Parthasarthy and Hammond [8]	<p>Functional integration:</p> <p>How are your product development activities organized? (1: strongly disagree, 4: somewhat agree, 7: strongly agree).</p> <ol style="list-style-type: none"> <li>1. Our product teams are always organized with diverse functional specialists.</li> <li>2. In our firm, communication among R&amp;D, manufacturing, and marketing groups is always formal and in writing (reverse coded).</li> <li>3. In our firm, R&amp;D single-handedly decides what new technologies will be pursued (reverse coded).</li> <li>4. In our firm, manufacturing engineers actively participate in product design.</li> <li>5. We rotate design and manufacturing engineers frequently.</li> <li>6. We always undertake product development sequentially, from R&amp;D to production to marketing, to achieve better control over each activity (reverse coded).</li> <li>7. In our firm, top management plays a supportive role in product development.</li> <li>8. Our reward system is more group-based than individual-based.</li> <li>9. Our structure and control mechanisms strongly promote cooperation among R&amp;D, production, and marketing groups.</li> </ol> <p>External integration</p> <p>Describe your unit's relationship with suppliers and customers (1: strongly disagree, 4: somewhat agree, 7: strongly agree).</p> <ol style="list-style-type: none"> <li>1. We always consult suppliers/customers on new product ideas.</li> <li>2. We always include suppliers in our product development teams.</li> <li>3. We always include customers in our product development teams.</li> <li>4. We freely share technical ideas with suppliers and customers.</li> <li>5. We always seek supplier/customer collaboration for developing new technologies.</li> <li>6. We always assist suppliers in improving component quality.</li> </ol> <p>Tool integration</p> <p>To what extent are the following manufacturing processes computer-integrated? (1: not integrated, 4: moderately integrated, 7: completely integrated).</p> <ol style="list-style-type: none"> <li>1. Product design/development and production planning.</li> <li>2. Product planning and component manufacturing.</li> <li>3. Component manufacturing and assembly.</li> <li>4. Assembly and quality control.</li> <li>5. Quality control and materials handling.</li> <li>6. Materials handling and storage/distribution.</li> </ol>

#### 4 CONCLUSION

Based on the above reviews and arguments, it is noted that innovation process is one of important part that contribute to the success of the whole implementation of organizational innovation. Due to its combination of complex activities, the need to come out with a good measurement is highly appreciated in the innovation research. One of the approaches is to divide between the objective and subjective kind of measurement. In establishing these indicators, researcher needs to identify the suitable operational definition of innovation process, characteristics (firm level, departmental level, group level or individual level) and innovation process generation. Nevertheless, being a researcher the rule of parsimonious must be applied due to the cost and time constraint. Hence, it is good to decide the measurements that are suitable, sufficient and efficiently used within the context of study.

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