

## FRONT-END OF INNOVATION METRICS: RESEARCH QUESTION AND LITERATURE REVIEW

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***Abstract:** A company's success is measured through growth, revenue and profits. However, one of the challenges that many companies struggle with is the ability to develop and grow new products and build an innovation pipeline. Often, companies fail to adopt a strategy to identify new trends that allow them to pivot, and by the time new entrants arrive into the market, it is too late.*

*The literature review considers Front-End Innovation (FEI) metrics to be a critical part of the innovation process. Currently, FEI metrics are the least valued in the innovation process and have not been fully developed or standardized. They are often inadequate, and do not allow for leaders and managers to make early, good decisions during the innovation process. This paper covers goes into a literature review of relevant research around FEI metrics and the ambiguity surrounding how FEI processes are measured.*

*Keywords:* Front-end of Innovation; metric; innovation; new product .

**Summary :** In many companies, reducing manufacturing costs to optimize profits is a common strategy used to compete in the marketplace by always seeking to reduce manufacturing costs and increase profits from year to year.

However, looking at cost optimization is no longer effective as new competitors emerge in the marketplace that deliver more value to customers. Companies must also compete by driving innovation in products and services in order to remain competitive in the marketplace. To

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effectively manage and assess the performance of an innovation pipeline, it must be measured which becomes difficult due to lack of standard approaches.

The following three dimensions of FEI are investigated in this article:

- Models
- Metrics
- Common language

*Keywords:* Front-end of Innovation; metric; innovation; new product .

## 1 INTRODUCTION

Companies are constantly under pressure to select the right ideas early in the innovation process. Resources and budget constraints limit the development of proposed ideas. New ideas and concepts that look promising in the innovation process often do not end up being successful. The main reason for this can be linked to the approach that these companies take in evaluating new ideas and their Front-End Innovation (FEI) Model. The difficulty in identifying successful ideas among a pool of candidates, is a result of the lack of time and resources devoted to the FEI assessment process (Dewangan and Godse, 2014; Kock, Heising, Gemünden, 2016) combined with the uncertainty that characterizes FEI. Often, companies fail to adopt a strategy to identify new trends that allow them to pivot, and by the time new entrants arrive into the market, it is too late. Historically, this has been seen with companies like Kodak and Blockbuster.

It has been shown that the most innovative companies have an efficient FEI process and effective metrics (Koen et al.; 2001). FEI metrics can be essential for organizational and strategic decision making (Hart et al., 2003) as well.

## 2 PROBLEM STATEMENT

Companies have always tried to avoid wasting their resources on wrong projects but at the same time they are asked to constantly innovate and generate new products. FEI metrics

help reduce uncertainty and allow companies to reduce the risk of failure and costs in later phases of new product development.

Managing FEI in high-tech industries plays an important role in providing opportunities to improve their overall innovation process and reduce the failure rate of new product development (Berg et al., 2009). Literature around this focuses on qualitative and indirect metrics to measure performance of a company's innovation process in order to highlight neglected FEI metrics. In general, it has been observed that there are more process metrics than product metrics that are used during evaluation of ideas (Dziallas, 2018).

Studies shows that a high number of indirect metrics combined with a low number of FEI metrics can be linked to the success of innovations. There is not enough focus on the details normally in the FEI phases which causes companies to falter (Eling and Herstatt, 2017). The majority of research on innovation neglects the understanding of models and metrics related to FEI (Klenner, Hüsigg and Dowling, 2013) even though they are essential for organizational and strategic decision-making (Hart et al., 2003).

The use of adequate metrics and effective evaluation approaches leads to improvement of innovation performance (Martinusuo and Poskela, 2011), and it can lead to significant growth in return on investment (ROI) and a considerable reduction in R&D costs (Reid and De Brentani, 2004; Verworn. Herstatt, and Nagahira, 2008).

The first stages of the innovation process require different metrics in comparison with the later stages (Hart et al., 2003). In addition, methods of measuring innovation recommended by scientific literature seem to be too theoretical and they are not easy to apply directly in practice (Adams et al., 2006; Cruz-Cázares et al., 2013).

The reason why measuring FEI is difficult is a result of several factors such as uncertainties and uncontrollable factors, precisely (Brem and Voigt, 2009; Herstatt et al., 2004; Khurana and Rosenthal, 1998; Kim and Wilemon, 2002; Ozer, 2007):

- It is difficult to gather information and manage FEI activities due to lack of existing FEI models in practice.
- FEI is a dynamic process and it is often unstructured and is difficult to standardize.

### 3 LITTERATURE REVIEW

#### 3.1 CREATIVITY AND INNOVATION

Creativity is the cornerstone and the seed of innovation, we cannot innovate without being creative. Creativity is the ability to create new ideas and to explore new ways of finding solutions to existing or new problems.

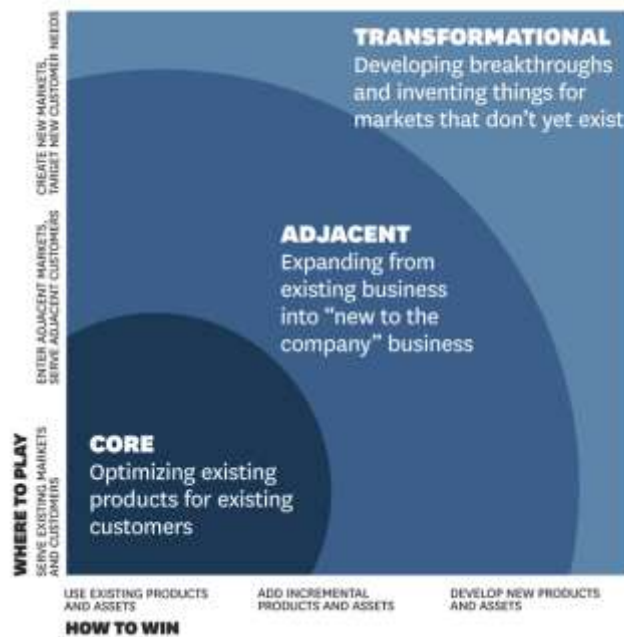
Tidd (1997) describe innovation as the process of converting opportunities into useful practice. In other words, it is the transformation of new ideas to products, services including new successful and useful business models with commercial value.

The Organization for Economic Co-operation and Development (OECD) defines innovation as the implementation of a new or significantly improved product, process or service. This definition also includes the commercialization of this innovation.

Innovation is a broad concept that can be understood in different ways. However, the differences in semantics become less pronounced when we consider innovation as a process rather than a single event (Trott, 2008). There are three types of innovation according to Innovation Ambition Matrix developed by Bansi Nagji and Geoff Tuff (2012):

- **Core innovation** (incrementally sustaining, “do better what you already do”): Making incremental improvements to existing product, technology or service.
- **Adjacent innovation** (new for the company): Expand from existing business capabilities into new business models to enter and serve customers in an adjacent market (for example: Google map, Android, etc.)
- **Transformational innovation** (disruptive/radical/breakthrough, new for the world): Focuses on creating new offering for new markets, transforming an existing market, or creating a new market (for example: iPhone, Tesla car, bone glue, etc.)

Figure 1– Innovation Ambition Matrix



Source: Bansi Nagji and Geoff Tuff (2012)

### 3.2 FRONT-END OF INNOVATION

The term "FEI" was first introduced by P. Koen, Ajamian, and Burkart (2001) to replace the term Fuzzy Front End (FFE) which was coined by Reinertsen in 1985. The reason for the replacement was to demystify the nature of the phase and to dispel the fuzziness which was attributed to FEI by identifying specific and structured activities which contribute to front-end success.

FEI begins when an opportunity is judged to be explored, evaluated. It ends when the company decides to invest in the new idea, devotes significant resources to its development in order to turn it into a product or service (Khurana and Rosenthal, 1998; Kim and Wilemon, 2002).

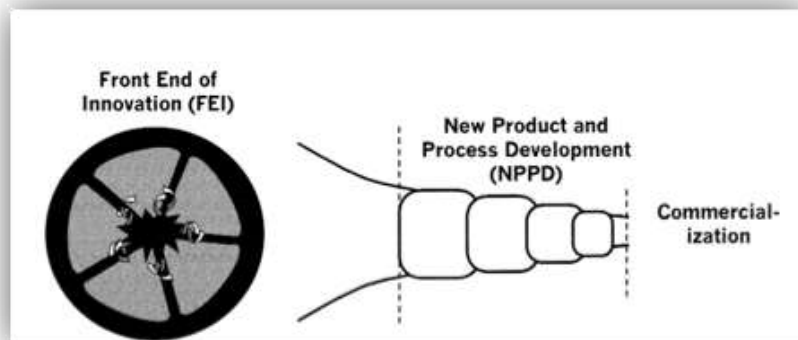
Khurana and Rosenthal (1998) emphasize that FEI includes: development of product strategy, communication, identification and evaluation of opportunities, idea generation, product definition, project planning and management reviews. According to Koen (2002), FEI is the phase where product strategy development, product identification, idea generation, idea

selection and concept development take place and decisions are made regarding development of new products.

Several researchers have helped to develop a generic high-level innovation process to distinguish the process into clearly defined stages. Cooper (2001) created a five-step version of his Stage-Gate ® process by combining some of the steps together. The division of innovation process was refined and divided into three phases (Koen et al, 2002) which are listed as below:

- **FEI**, this phase encompasses ideas generation, ideas evaluation and definition of the new concept.
- **New Product and Process Development (NPPD)**, this is the second phase , it contains the tasks aimed at developing, testing and verifying the concept of the product (or process) idea as output of the first phase.
- **Commercialization**, this is the third and last phase of the innovation process, and includes the tasks aimed at marketing the newly developed product (or new process).

Figure 2 – The Three Phases of Innovation Process



Source: Koen et al. (2002)

### 3.3 THE IMPORTANCE OF FEI

The early stages of the innovation process (FEI) have the greatest impact on the end result of the project and provides the highest potential ROI. Therefore, FEI is often described as the main cause of the success of any business desiring to become more innovative compared



to their competitors. Backman, Borjesson, and Setterberg (2007) added that the best opportunities to improve the overall innovation process are in the FEI process.

Researchers have recognized that FEI activities are critical in the innovation process, as it is the main step that creates added value and paves the way for the successful development of new products (Koen et al. 2002; Reid and De Brentani, 2004). Also, they added that FEI is the main driver for the success of new products (De Oliveira et al., 2015; Kock et al., 2015; Reid and De Brentani, 2004; Verworn et al., 2008; Zhang and Doll, 2001).

### 3.4 THE DIFFERENCE BETWEEN FEI AND NPD

The activities of FEI process are chaotic, unpredictable and unstructured. In contrast, the New Product Development (NPD) process is generally structured, disciplined, and predictable. NPD contains formal activities oriented towards objectives which are predefined and deterministic (Koen et al., 2002).

Table 1– Comparison between FEI and NPD process

| Difference Between the Fuzzy Front End (FFE) and the New Product Development (NPD) Process |  |  |
|--|--|--|
|  | Fuzzy Front End (FFE)  | New Product Development (NPD)  |
| Nature of Work   | Experimental, often chaotic. "Eureka" moments. Can schedule work—but not invention.                            | Disciplined and goal-oriented with a project plan.   |
| Commercialization Date   | Unpredictable or uncertain.  | High degree of certainty.  |
| Funding  | Variable—in the beginning phases many projects may be "bootlegged," while others will need funding to proceed. | Budgeted.  |
| Revenue Expectations   | Often uncertain, with a great deal of speculation.   | Predictable, with increasing certainty, analysis, and documentation as the product release date gets closer. |
| Activity   | Individuals and team conducting research to minimize risk and optimize potential.                              | Multifunction product and/or process development team.   |
| Measures of Progress   | Strengthened concepts.   | Milestone achievement.   |

Source: Koen et al. (2002)

### 3.5 INNOVATION AND FEI METRICS

Most of the literature surrounding FEI metrics focuses on improving cycle time of NPD (Murphy & Kumar, 1996). However, a lack of any of the following items: vision, priority, development, effective project leadership in the FEI, even effective staff communication leading the FEI (Kim and Wilemon, 2002; Rosenau, 1988) can lead a company to delays, increased costs, the loss of opportunities to launch new products, and the inability to gain a competitive advantage.

The performance of FEI has also been measured in some academic research by its effectiveness and efficiency (Chen, Chang and Lin, 2010; Verworn et al., 2008; Wagner, 2010). Efficiency means doing things right with a focus on the process. From a process point of view, the efficiency of FEI performance relies on an optimal use of resource expenditure such as time and cost. Effectiveness is about doing the right things, with an emphasis on the end result. From a results standpoint, the effectiveness of FEI's performance is based on achieving FEI's expected results which can include explicit and stable products, product concepts and innovative ideas. From a broader perspective, different metric types were found in literature:

- **Direct and Indirect Metrics** (Becheikh et al., 2006): direct metrics are the metrics that directly influence the success of innovation. In contrast, indirect metrics are metrics which partially measure innovation.

Dewangan and Godse (2014) gave an example of a direct metric as the percentage of ideas found viable for marketing. Regarding indirect metrics, some examples include the novelty of the business model according to Duhamel and Santi (2012), the "planning and control of the innovation process" according to Huergo (2006), the number of patents according to Hagedoorn and Cloudt (2003), the budget devoted to R&D (Flor and Oltra, 2004), the number of new product ideas (Cooper and Kleinschmidt, 1993), financial results (outcomes metrics) according to (Chan et al, 2006).

- **Composite or mixed metrics:** suggested by Patel and Pavitt (1995), and by Grupp and Schubert (2010), they recommended to use composite metrics in order to be able to



measure multi-aspects of innovation, for example using ratio of two different metrics to cover two or more innovation aspects as ROI for example.

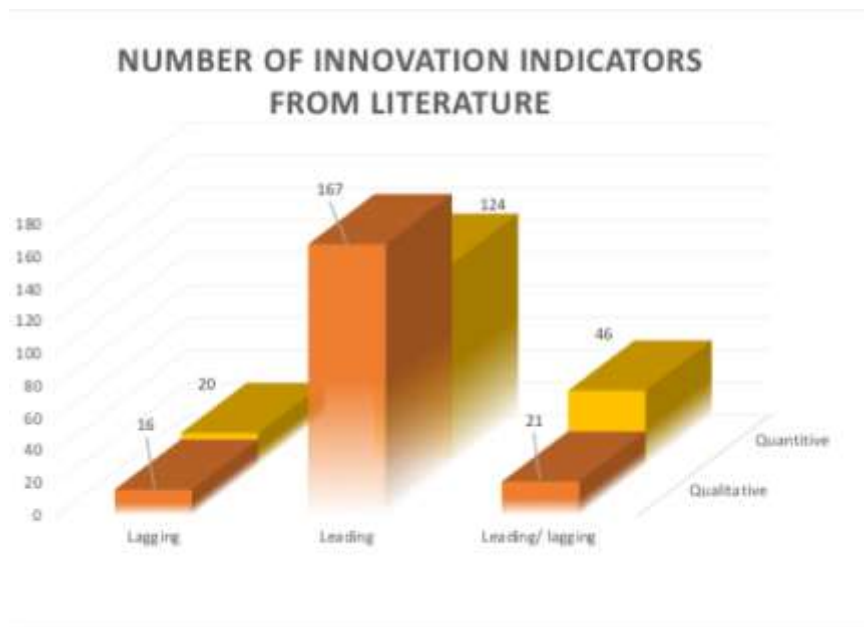
- **Input, throughput, and output metrics** : according to other researchers as Klomp and Leeuwen (2001), they are known also as process metrics which focuses on innovation process (examples: time to profitability, time to market, etc.)

According to G. Fankhauser (2019), over 200 innovation metrics were mentioned in more than 400 publications and can be classified by the :

- **Process phase:** comparing input, throughput and output metrics and often known as leading (predictive) or lagging (reporting) metrics.
- **Area of measurement:** these can be related to product development, strategy, organisation, culture, etc.
- **Expression** in qualitative or quantitative terms.

The below graphic illustrates types of innovation metrics found in academics articles released in the last decade (G. Fankhauser, 2019).

Figure 3– Qualitative metrics dominate literature : Leading metrics are more abundant than Lagging metrics



Source: G. Fankhauser (2019)

### 3.6 LACK OF COMMON UNDERSTANDING OF INNOVATION

The literature review has shown that there isn't really a common understanding of the innovation process, likely as a result of its complexity and various influencing factors (Dodgson and Hinze, 2000; Becheikh et al., 2006).

According to Edison and other authors (2013), a consistent measurement strategy currently doesn't exist that can adequately assess innovation. As a result of this, measuring innovation is still an elusive goal for many companies (Andrew et al., 2008). Without a common framework and vocabulary to describe innovation, the ability to create new knowledge and make distinctions between different organizations may be impossible (Krogh, Ichijo and Nonaka 2000). Similarly, the understanding of FEI is unclear compared to the other subsequent phases of the innovation process (Cooper, 2008; Barczack et al., 2009).

Finally, Eling and Herstatt (2017) states that the FEI needs more detail and clarification. So, clear definition of metrics can help companies manage their innovation process better (Kerssens-van Drongelen and Cooke, 1997).

### 4 FEI MODELS

FEI activities have received special attention from researchers as a result of the opportunity to improve management of new products and FEI measurement (Smith and Reinertsen, 1991; Cooper, 1997; Khurana and Rosenthal, 1997).

Khurana and Rosenthal (1998) states that the problems of FEI management are caused by the lack of disciplined execution of FEI activities rather than an underlying confusion about what should be done. As a result, over past two decades, several researchers and companies have suggested different approaches to manage FEI activities but most of innovation models focuses partially on FEI management, hence the difficulty in measuring FEI performance.

Table 2– FEI models focused on phases prior to Development phase

| Author(s)                   | Description  |
|-----------------------------|--|
| Smith and Reinertsen, 1991  | Three stage Front End Model.<br>Stage 1: Project Proposal<br>Stage 2: Business Plan<br>Stage 3: Detail Project Plans & Product Specifications  |
| Paul, 1996                  | Three Step Front End Model.<br>Step 1: Idea screen<br>Step 2: Concept Development and Testing<br>Step 3: Business analysis   |
| Khurana and Rosenthal, 1997 | A Three Phase Front End Model.<br>Pre-phase Zero: Preliminary Opportunity Identification and Market and Technical Assessment; in Parallel with the Product and Portfolio Strategy Evaluation<br>Phase 0: Product concept is defined<br>Phase 1: Product feasibility and project planning |

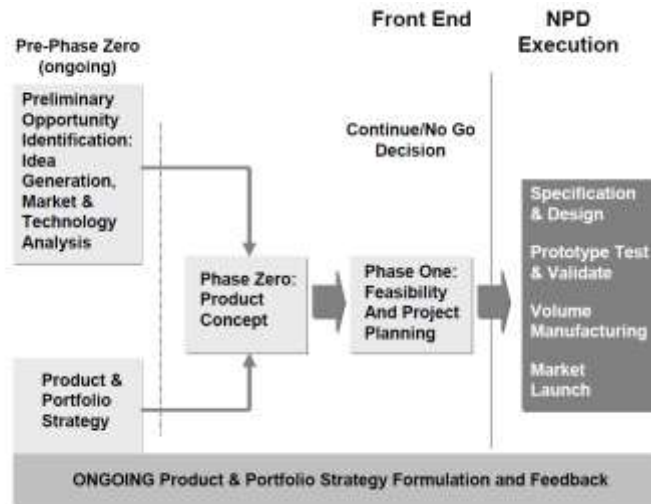
Source: Tippett and Carbone (2004)

#### 4.1 SEQUENTIAL MODEL FOR FEI

In the stage-based innovation process models (action-stage and decision-stage models), the FEI activities are sequential. Actions are executed in sequential and linear manner with decision gates between them (Cooper 2001, Khurana and Rosenthal 1998).

The Three-Phase “Front end” model proposed by Khurana and Rosenthal (1998) is an example of a sequential model for FEI. Sequential models are not really suitable for FEI to the nature of the model. In practice, the activities are generally executed in a non-sequential order and re-iterated several times by refining the ideas (Koen et al. 2001). The model should not force activities in a rigid sequence by defining gates between the sub-phases (ideas generation, idea selection and concept definition). However, the main advantage of sequential model is a focus on decision gates and give a clear flow of activities.

Figure 4– Three phases FEI model



Source: Khurana and Rosenthal (1998)

## 4.2 DYNAMIC MODEL FOR FEI

Unlike sequential models, dynamic models are iterative and strongly supports parallel activities. This gives more flexibility to the model since the activities can be performed in the best order, and be iterated as many times as necessary to narrow down and achieve a successful solution.

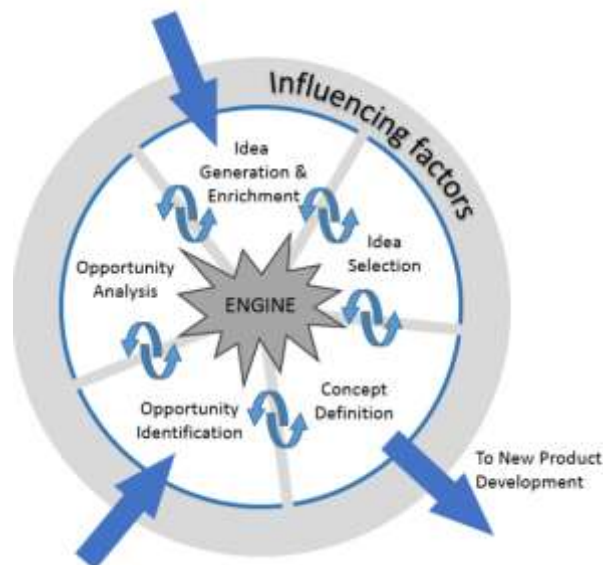
According to Koen (2001), few studies have been carried out on FEI best practices. Several practices are developed in the development phase of new products which do not apply in the FEI. For these reasons, a project team from the Industrial Research Institute (IRI) studied FEI with the aim of developing most effective practices in eight companies: Air Products, Akzo Nobel, BOC, DuPont, Exxon, Henkel, Mobil and Uniroyal Chemical. IRI demonstrated that it is impossible to determine FEI best practices within those companies due to differences and lack of common language and common vocabulary used in FEI activities and process within those companies.

To overcome the above shortcomings, a New Concept Development (NCD) model was developed by Doctor Peter Koen and other authors in 2001. The NCD model was born to provide a common language and necessary terminology (opportunity, idea, concept and

product) to understand and optimize activities which occurs during FEI. The NCD model divides the FEI into three distinct parts (Koen et al., 2001):

- **The Engine**, which is the center of the model that powers and drives FEI through the vision, leadership, strategy and culture of the organization (things that are relatively controllable).
- **The Wheel**, defines the five elements of FEI activities as opportunity identification, opportunity analysis, idea generation, idea selection and concept definition. The NCD model is circular to show that ideas can circulate and iterate between the five elements. The project begins with either the identification of the opportunity or with the generation of the ideas and it leaves the FEI towards Development process of the new product, once the concept is defined.
- **The Rim (Influencing factors)**, represents the environmental factors (things that are relatively uncontrollable) which influence the “Engine” and the five elements (the Wheel) of NCD model such as customers, competitors, suppliers, government regulations, technology, organisational capabilities, etc.

Figure 5– NCD Model



Source: Koen et al. (2001)

The main drawback of the dynamic model is the confusion around when to eliminate or to accept new ideas, lack of a Go/No-Go gate to minimize risks and uncertain flow of FEI's activities (Mat Kamil Awang, s.d). Since the model is iterative, it gives more flexibility in addressing the complexities and the uncertainties of FEI.

## CONCLUSION

The understanding and the management of FEI processes is still limited and unclear in actual literature. This is largely due to the variances in definition of FEI and model that are used to evaluate and select the right ideas early in the innovation process (Huang et al., 2020). This illustrates the importance of using standardized processes and vocabulary across organizations for FEI, so that metrics could be measured and compared between organizations in order to make effective and earlier decisions in the overall process .

Examples of such metrics could include number of generated ideas, where the health of the FEI process is measured by evaluating the number of ideas coming into the pipele; number of implemented ideas to see which reach a productization phase; Time to profitability to evaluate the average time to re-coup investments on development of products around new ideas. By proposing such standardized models and processes, companies can stand to benefit with more consistency in how to bring new products to the market with less risk.

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