A Study of Implications of Historical Models in Innovation Management in IT Industry

[1]Saksham Khandelwal, [2]Dr. B. B. Taywade
[1]Research Scholar, Dhanwate National College, RTMNU, Nagpur, India
[2]Former-Principal, Dhanwate National College, RTM Nagpur University, Nagpur, (MH), India.

Abstract: **Innovation is a production or adoption, integration, and exploitation of value-added originality in fiscal and social domains; renewal and expansion of services and products, development of new procedures of production; and launching of new management schemes. It is both a progression and an outcome that lead to commercialization. There are various models. This paper focuses on the study on Linear Model and Stage-Gate Model. The study is to discuss the structure of the earlier model based on R&D and the need to develop new models of innovation to leverage technology advancements and effectively contribute towards economic as well as scientific systems.**

Index Terms- Innovation, Linear Model, Stage–gate model, R&D

1.Introduction

In literature around innovation, two major dimensions emerge that are consistent across various proposed models for innovation management. They are the degree of novelty which is reflected through patents and protected intellectual property. It is original to the firm, the market, the industry, or the world and nature of innovation. The other aspect revolves around the process or product-service system innovation.

Innovation includes not only original invention but also its efficacy and uses to the society. Innovation is the generation, admission, and realization of new ideas, products, services, and processes. The first theoretical framework was developed for historically understanding of science and technology and its relation to the economy. Historical models of innovation are meticulously related to new scientific discoveries and fundamental research in applied research, technical applications.

Innovation management is a relatively recent management discipline. The models which are a theoretical construction of ideas were welcomed by industrialists, consultants and business schools, seconded by economists. In projects that required funding for fundamental research from sources like governments, the groundwork and processes that emerged out of this model helped to create appropriate frameworks and give wide acceptance to the model, despite regular criticisms. Through models, knowledge is exposed in universities, transferred on to organizations via publications, patents, and other forms of scientific correspondence, and finally to customers in the form of a product or service. They are best for organizing economic research on the social benefits of scientific research. The earlier models helped in explaining the role of science in industrial innovation.

Figure 1: Innovation Approach Model

The "linear model of innovation" is known as the foundation of present models. The model claims that innovation starts with basic research, followed by applied research and development, and ends with production and diffusion. In addition to the Linear, "Assembly-line model," (Wise, George,1985) , "Stage-Gate Model", "Pipeline model" (Alic J et al. , 1992) (Fumio Kodama, 1995) "Ladder model," (Gomory R,1989) and the 'Bucket model' got popular.

II. First, Second and Third Generation Innovation Models

The linear model, the first generation of innovation models also called as "Technology push" model and is very close to "science push." These are distinctive representatives of the years 1950-1960.

The second generation models are alike their predecessor except that; innovation idea is drawn from the marketplace. Research and Development and science are the key factors in the development of the first generation models. The second generation of models was developed during 1960-1970 and are known as models of "market pull" and are all linear. These are linear models including "Technology push" and " Need pull." The "Need pull" or "Market Driven" models were developed after "Technology push" model. "Science leads to technological breakthroughs which played the main role in the introduction of new products and processes on the market." They were focused on recognizing the importance of market demand and supply technology to potential customers.

During 1980-1990 scientists were interested in specific processes that have been generated by new technologies and knowledge required by new technologies.

Interactive models are the third generation of innovation models which included coupling models and integrated models. These model correspond to the innovation process, which can be considered as a communication complex network. It integrates or links various components such as intra and extra-organizational, various individual functions, the scientific community, and the technology market.

III. LINEAR MODEL: THE FOUNDATION OF PRESENT AND UPCOMING MODELS

The structure of the Linear model of innovation was created for basic research and development. It looked at innovation in a linear process that began with fundamental research and led to successful deployment (R.R. Nelson, 1959). For almost five decades, this model has played a decisive role in the evolution of the tacit technology strategies of most industrial nations.

The linear model is based on a simple fact that innovation takes place in sequential and distinct stages. Research is the initiating step. It is the foundation of all innovations. The Linear model depicts that a standard and predominant path of innovation in both firms and national economies start from research travels through development and results into production. There is no feedback path into the system. The Linear model has also played its role in being used as a justification for doing basic science research in the US. (Poncelet E, 1986) It provides the conventional wisdom which underlies most policy discerning about technology development and economic growth.

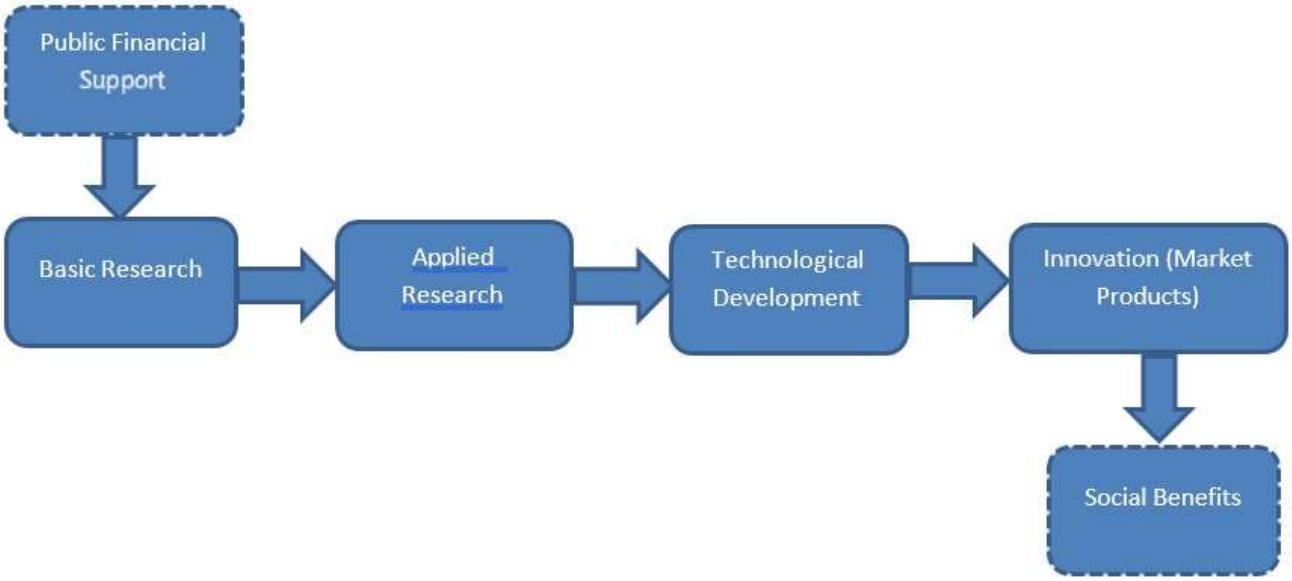

Figure 2: Linear Model

The structure of the Linear model of innovation was created for basic research and development. It looked at innovation in a linear process that began with fundamental research and led to successful deployment (R.R. This model characterizes innovation as a linear process in which prior scientific research is followed by technological change. Thus, this R&D model is named as The Linear Model of Innovation where serial events take place with reference to time and not linearity in the sense of a linear equation.

Linear Model established its relevance and prominence for around five-decade as science and technology policies have consistently evolved with the Linear model of innovation. (Mahdjoubi, D., 1997) This model has primarily, perhaps exclusively focused, on government-funded R&D which were conducted at government laboratories or in universities. Along with this foundation of policies like economic 'market failure' and Keynesian economic, which justified government intervention to lift and sustain employment crises became the key factors during that era. Thus, government grants for research and development remain a popular policy in keeping with the Linear model.

IV. A STAGE-GATE MODEL APPLIED TO INNOVATION PROJECTS

While novel ideas provide firms with the direction to create product or services, the success is dependent on the capability to successfully bring the concept to market. Most organizations have historically relied on the stage-gate model to commercialize their ideas. An innovation project is alienated into distinct stages or phases. These stages are separated by decision points, known as gates. At each gate, a decision is taken, whether to continue further or not. This decision is made on the prognosis and information available such as business case, risk analysis, availability of required resources (e.g., money, people with correct competencies) at that moment.

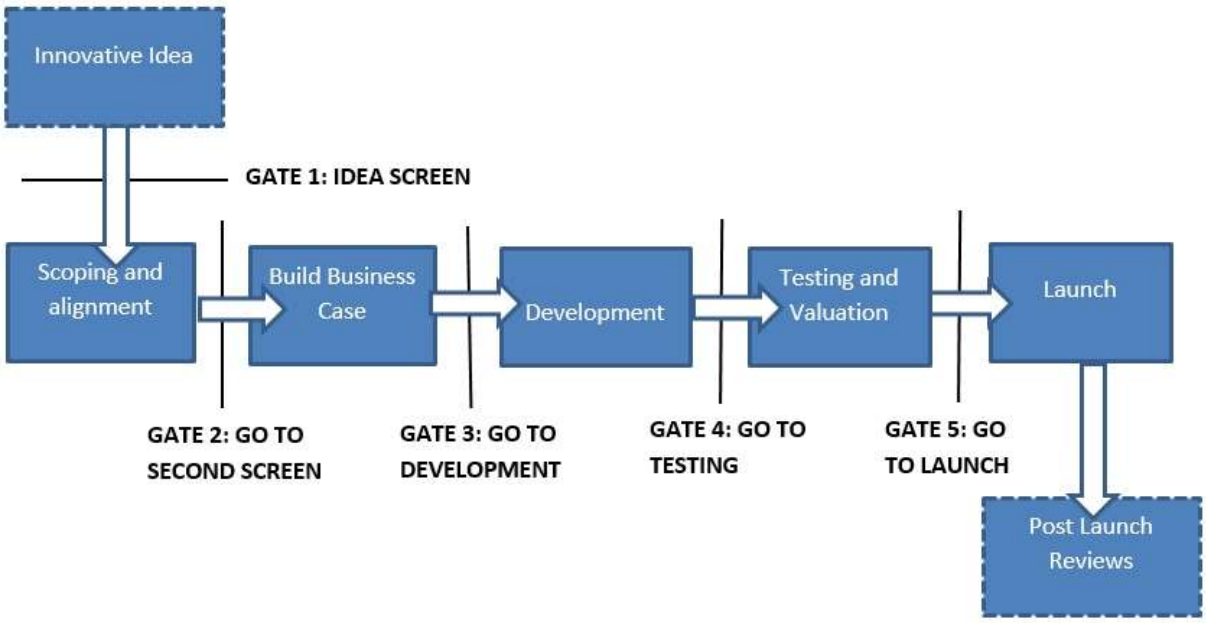

Figure 3: Stage-Gate Model

- **GATES:**

At each gate, the quality of an idea is assessed. For successful execution of the project, the action plan is critically examined. Subsequently, at each gate, one of the following decisions can be made.

- Go: The project is recommended to move ahead to the next stage.
- Kill: The project is not recommended to shut down immediately.
- Hold: The project is not recommended to continue further at this moment but need not shut down immediately. It can be put on hold and resumed later.
- Recycle: The project, can be further developed if and only if some modifications are done. (Cooper et al., 2012)

- **STAGES:**

The Stage Gate model comprises of a number of stages. These stages inter-connected to each other through gates. Each stage is designed to gather specific information:

- Stage 0: Discovery of an innovative idea
- Stage 1: Scoping
- Stage 2: Business plan concept
- Stage 3: Development
- Stage 4: Testing and validation
- Stage 5: Launch and implementation

Depending on the size of the project, 2, 3 or all 5 stages are completed. A project that focuses on significant product innovation will go through all 5 stages. A project with less risk will suffice with just stage 1 (scoping) and stage 2 (development of the business plan) and developing it to stage 4 (testing and validation). With very small or straightforward adjustments, only stage 3 (development) and stage 4 (testing and validation) will be implemented. Examples are marketing requests or an application to modify an existing product. (Mulder, 2018).

This model is being used while developing new products, software development, process improvements. The stage gate model offers a standardized way of accomplishing an innovation. This model trusts on loops of feedback. This makes it efficient and interactive.

All the teams involved in the process share a common platform. Hence, there is a transparent communication among the team and with the top management. IBM, General Motors, Northern Telcoma, and 3M are few who have used this model in all their innovations. The companies report that the model empowered them to achieve success in their innovation processes.

It helps in reducing production errors, facilitates to focus on clarity of all planned projects. It provides good communication between external stakeholders, including customers, partners, and suppliers. It has the ability to identify problems and assess progress before the conclusion of the project. This model helps to reduce the complexity of large projects. The quantitative information in respect to feasibility of developing potential product ideas can be provided when a stage-gate process integrates cost and fiscal analysis tools such as net present value. (Nielsen, Dave, 2008)

On the contrary, the gates are demanding in the first stages of concept and idea generation. The major drawback of Stage-gate Model is that there are potential chances of interference between the structural organization with the creativity and innovation which may result in creativity to be reduced.

V. DISCUSSION

DEFICIENCIES IN THE EARLIER MODELS

Following parameters play pivotal role and appear to be of great importance in all models.

➢ COMMON DEFINITION FOR R&D

Earlier Models fail to provide a particular definition of R&D in different circumstances. It says "Industrial R&D," is one which focuses on the development side of R&D and is different from the "Academic R&D" which inclines more to basic research.

➢ INNOVATION: MUCH BROADER THAN R&D

First generation models mainly focus on R&D for product development and are aimed at introducing genuine invention. It may be major or radical innovation. The R&D has often been equated with innovation. If so, understanding innovation would be far simpler than it truly is. For successful innovation the coupling of the technical and the economic is needed in a way, that can be accommodated by the organization alongside meeting market needs. This aspect was taken care of by Second generation models. Still, it was felt that this requires close coupling and cooperation among many activities in the marketing, R&D, and production functions (Kline S, and Nathan Rosenberg, 1986)

The complex processes of technological accumulation were ignored by formal R&D whereby unspoken, partly un-codified knowledge is built up and is communicated from one generation to the next inside organizations, firms, and whole industries. Formal R&D does not emphasize the relationships between organizations, the feedback processes or the alliances and relationships of power between agencies and firms (Chesnais F, 1993)

However, the innovation management in any country in IT and other sectors do not depend solely on the scale of R&D (as per the linear model). It is dependent on other technical activities as well. Third generation models focused on this issue but the way in which the availability of resources are innovatively managed and organized, also play a vital role remained unnoticed (Freeman C, 1982)

➢ ATTENTION TO DESIGN ENGINEERING AND PRODUCTION

The Linear model deviates from the fact that the central process of innovation is not science but design. Contrary to this, the initiating step in most innovations is not research but is a design. The term "design" in the Innovation process is used to symbolize a study of new combinations of existing products and components, rear-arrangement of processes, and planning of new artifacts within the existing state of the art.

Significant innovations leading to evolutionary changes have happened in the past, without any support from R&D is a well-established fact and cannot be denied. (Lundvall B, 1992)

➢ ATTENTION TO FEEDBACKS, INCREMENTAL INNOVATION AND REVERSE ENGINEERING

Innovation originates from informal learning by doing, by using, and by interacting. Know-how of product and understanding customers' requirements are the major sources of incremental innovations and product customization. Feedbacks are an intrinsic part of development processes. Innovation does demand feedback. It demands rapid, accurate feedback with appropriate follow-on actions. Feedback paths do not exist in the Linear model.

VI. CONCLUSION

The Linear model gained popularity and has often been used implicitly for over five decades. A model that defining innovation as a single process, or attributes its sources to a single cause, or gives a straightforward picture, indeed distort the reality and thereby prejudice our thinking and decision making. The Stage-Gate Model gained industry adoption. Although the model is found useful but is inappropriate in respect to radical innovations. Thus, a more flexible, learning-based approach model is needed to address the era of the fourth industrial revolution where multiple technologies shape the market.

Recent studies on the technology development process strongly suggest that innovation should not be limited to a linear process. "For ages, there is a saying that "innovation is achieved by breaking through the limitations of existing technology." Recent innovations put a light on innovation as it is the fusion of different types of technologies, rather more than a combination of different technologies. Such fusion has been visualized getting promoted through IT industrial policies. The shift in innovation patterns in need of the hour. The journey from breakthroughs to fusion is contained in the other dimensions of the techno-paradigm shift.'

The development of non-linear innovation models is needed to incorporate the linking of knowledge in economics and the development of economic policies with innovation. Consequently, the introduction and development of new models of innovation are required to make the desired effect in commercial as well as scientific systems.

Nowadays, factors like design, multiple data source, technologies like IoT, AI, play a role of initiator of the central-chain-of-innovation cannot be denied. Acknowledging current computer capabilities, availability of extensive data, decreasing cost of computing, it is nearly certain that one can visualize a merging of design, technology, and core invention in the coming decades.

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