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Article

Evolution and Models of Innovation Processes in the Digital Economy

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Abstract: This study examines the evolution of innovation processes within the digital economy, tracing the development from early models of technological impetus to contemporary frameworks based on information technology. Despite extensive literature on innovation models, there remains a gap in understanding the integration of digital tools in modern innovation practices. Employing a historical-analytical method, the research analyzes six generations of innovation models, emphasizing their transition and adaptation to market saturation and technological advancements. The findings reveal a significant shift towards the strategic incorporation of digital technologies, enhancing efficiency and market responsiveness. The results underscore the importance of evolving innovative strategies to maintain competitiveness in a rapidly digitizing economy, offering critical insights for policymakers and business leaders aiming to harness the full potential of digital innovations.

Keywords: model, innovation, evolution

1. Introduction

The innovation process has undergone significant transformation over the past several decades, evolving from early models of technological impetus to sophisticated frameworks that integrate information technology and market dynamics. Previous works by scholars such as Roy Rothwell [1] and A.V. Tebekin have classified these evolutionary stages into distinct generational models, each reflecting the prevailing economic and technological conditions of their times. Despite the extensive body of literature on innovation models, a notable gap remains in understanding how these models adapt to the rapidly digitizing economy and the specific role of digital technologies in driving modern innovation practices.

This study aims to address this gap by employing a comprehensive historical-analytical methodology. By tracing the development of innovation models from the 1950s to the present, the research provides a detailed analysis of six generational models: the technology push, market pull, coupled innovation, integrated innovation, strategic networks, and the innovative model of information technologies. The study utilizes both primary and secondary data collected from academic journals, books, and credible online databases to ensure a robust and thorough examination of each model's characteristics and evolution.

Previous works have primarily focused on the theoretical aspects of these innovation models and their implementation in various industrial contexts. However, there has been limited exploration of how these models have integrated digital tools and technologies in response to market saturation and technological advancements. By conducting case studies of leading companies such as Total, LG Chem, SABIC, and BASF, this research provides

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empirical evidence of the practical application and transition between different innovation models. The comparative analysis of these case studies highlights the key challenges and successes experienced by these companies, offering valuable insights into the strategic incorporation of digital technologies in modern innovation processes.

Historically, there have been several models of the innovation process. The structural description of the generations of these models was reflected in Roy Roswell, who proposed a classification of models of the innovation process. This classification includes a model analysis of the development of innovative processes in the 1950s and 1990s years. Roswell identified five generations of the innovation process:

- model – "technology push" (G1);
- the "market attraction" model (market pull) (G2);
- coupled innovation model (G3);
- integrated innovation model (G4);
- innovative model of strategic systems and networks (G5).

Currently, scientists confirm the existence of the sixth generation, which is called "the concept of an innovative model of information technologies" (G6) [2].

In conducting this research, the study synthesizes findings from multiple sources and perspectives to present a coherent narrative on the progression and current state of innovation processes. This approach not only fills the existing knowledge gap but also provides critical implications for policymakers and business leaders aiming to harness the full potential of digital innovations in a rapidly changing economic landscape.

2. Materials and Methods

The methodology for this study involved a comprehensive historical-analytical approach to explore the evolution of innovation processes and models in the digital economy. The research began with an extensive literature review, sourcing seminal works by key scholars such as Roy Rothwell and A.V. Tebekin, among others, to map out the foundational models of innovation from the 1950s to the present. Primary and secondary data were collected through academic journals, books, and credible online databases to ensure a thorough understanding of each innovation model's characteristics and the contextual factors driving their development. The study specifically focused on six generational models: the technology push, market pull, coupled innovation, integrated innovation, strategic networks, and the innovative model of information technologies. Each model was analyzed for its theoretical underpinnings, implementation strategies, and practical outcomes in various industrial contexts.

Case studies of leading companies, such as Total, LG Chem, SABIC, and BASF, were examined to illustrate the real-world application and evolution of these models. These case studies provided empirical evidence of how companies transitioned from one innovation model to another, highlighting the challenges and successes experienced during these transitions. Furthermore, a comparative analysis was conducted to identify the key differences and similarities between the models, with a particular focus on how digital technologies have been integrated into modern innovation practices. Data triangulation was employed to ensure the reliability and validity of the findings, drawing from multiple sources and perspectives. The results were synthesized to present a coherent narrative on the progression and current state of innovation processes, offering insights into future trends and implications for practice.

3. Results and Discussion

The "technology push" model, also called "science push" or "proactive model", was developed in the 1950s. This model is represented by a linear sequence of cyclically repeating stages of the innovation process (Figure 1).

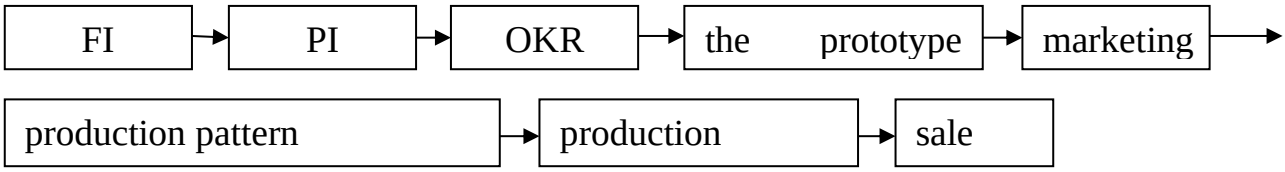

Figure 1. The "technological push" model (G1)

At each stage of the innovation process, a result must be obtained, which is used as a resource for the next stage. At the beginning of this sequence lie the fundamental developments of science and technology, at the end-the development and introduction of innovations into production.

As an example of a model for the implementation of a "technological push" in the implementation of innovative processes in the chemical industry, the French oil and gas company Total can be cited, as well as LG Chem, the largest chemical company in Korea. These companies have been intensively engaged in development and research for further innovative breakthroughs. At that time, it was R&D that played the dominant role in production, so at that timea large number of research laboratories were created. But already at the turn of the 1960s and 1970s, the disadvantages of this model became obvious.

It paid almost no attention to the sale of the product on the market, as a result of which R&D expenses were not covered. There was a problem of oversupply of the product, and the difficulty of selling it. Companies needed to switch from R&D to market research and its needs. Projects are being created in order to efficiently allocate resources. This, the “pull market” model was developed (Figure 2).

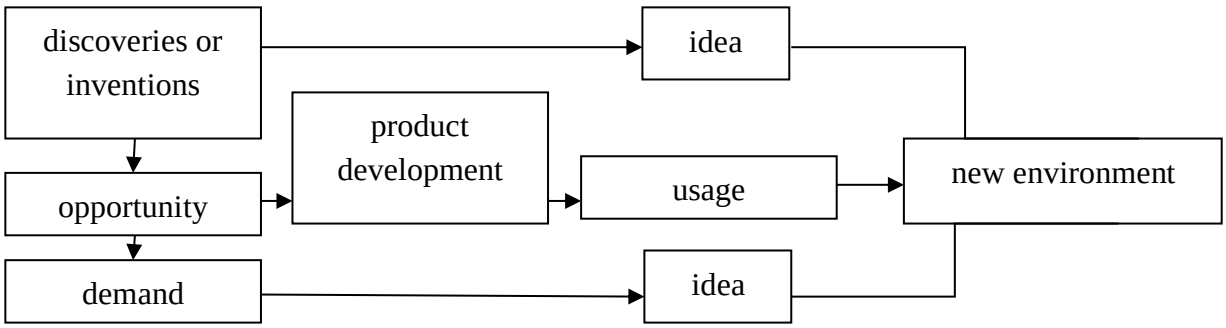

Figure 2. The second generation of the innovation process (G2)

In the "market attraction" model, the impetus is market demand. It was believed that innovations are beneficial if you rely on the desire of the consumer.

Demand set the direction for scientific developments, and then a linear process followed, as in the "technological push". Therefore, this is also a linear sequence, but with the advantage of relying on market needs. An example of the implementation of the "market attraction" model is the innovative activity of SABIC in Saudi Arabia, which developed useful chemicals, polymers and fertilizers for the market. There were disadvantages in this model, the main of which is the linearity of the sequence in a nonlinear process. Such a model seriously limited the company's constant search for innovations, taking into account the consumer's desire for this. In the 70s of the XX century, linear models G1, G2 began to be considered only as special cases of a more general process combining science, technology and the market. The research of such authors as R. Roswell, K. Freeman, A. Horsley, A. Jervis, D. Townsend, D. Movery, N. Rosenberg and others confirmed the importance of marketing, marketing and technical factors for successful innovation. There is a need for a new, already nonlinear, model. R. Roswell, based on the experience of models G1 and G2, has identified three more models of innovative development.

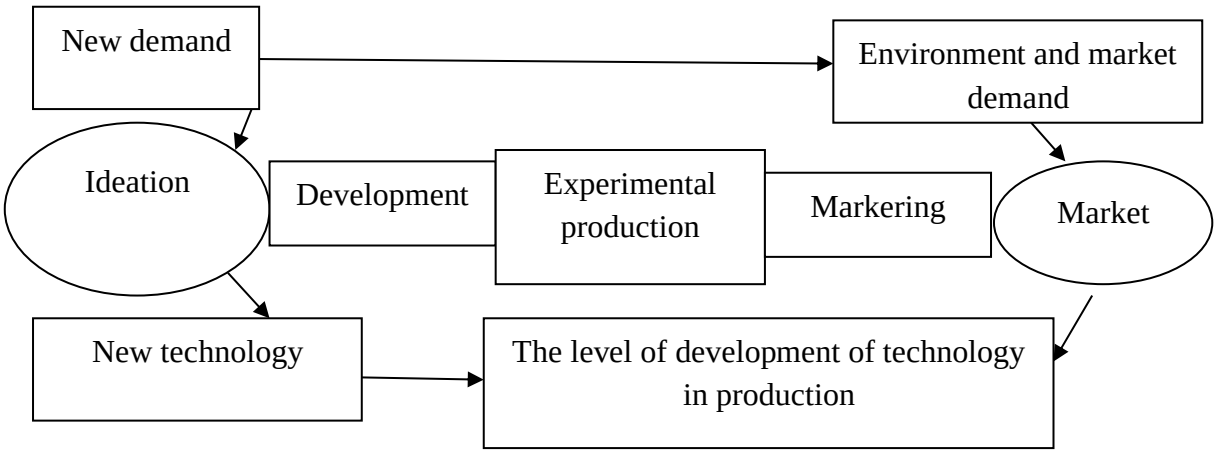

Figure 3. Coupled Innovation Model (G3)

The third model is notable for the fact that in addition to the linearity of the process, there are various feedbacks and network interactions. The coupled model isa composite model of the first and second generation, taking into account technological capabilities and market needs [3].

Such a model was used by companies such as, for example, Inte co (a Russian company doing business in the field of construction, development and petrochemistry), as well as CJSC GC Titan (a Russian corporation, one of the largest companies in the CIS engaged in the production and marketing of synthetic rubber, phenol, as well as developments in the field of biotechnology).

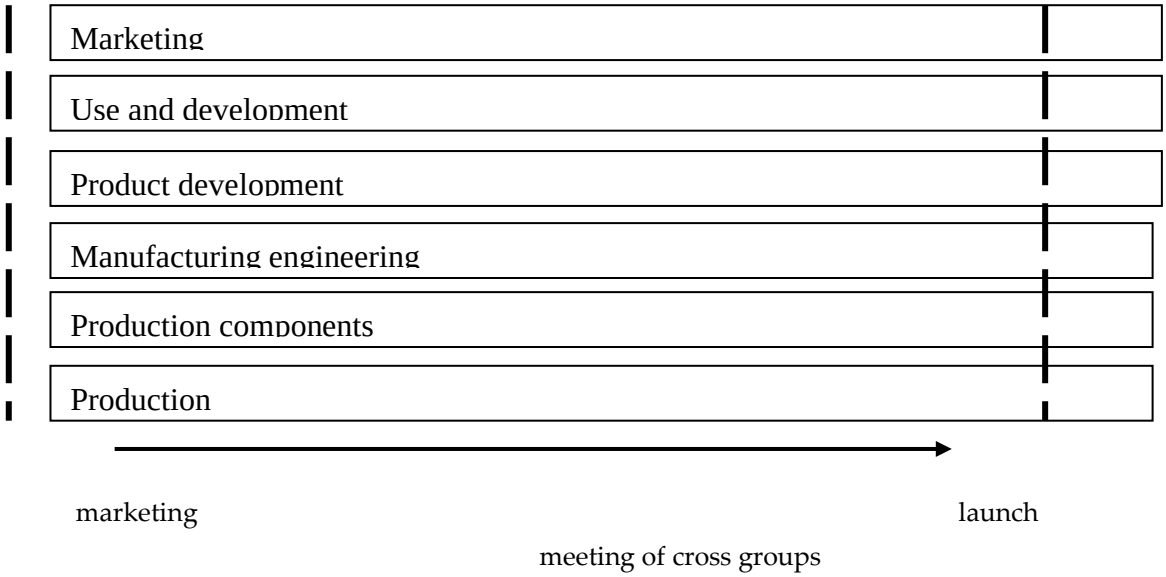

Figure 4. Implementation of the integrated innovation process (G4)

Examples of the implementation of the G4 process in the chemical industry can be found in the innovative activities of companies such as Formosa Petrochemical Corp. (Taiwan Petrochemical Company), Sinopec Corp. (Chinese integrated energy and chemical company). Since the 1990s, innovation processes have been further accelerated as a result of market saturation. An innovative model of G5 strategic networks and systems is emerging. This model reflects the interaction of various institutions, resulting in which is an innovation.

The innovation process is difficult due to some reasons. For example. A successful idea needs to be identified early in the process. In addition, the process of conducting product research and development is quite expensive. Therefore, it is necessary to bring exclusively promising ideas to the development stage.

This selection of ideas and their transformation into a product can be illustrated by the "Funnel" model presented by Steven Uylwright and Kim Clark (Figure 5).

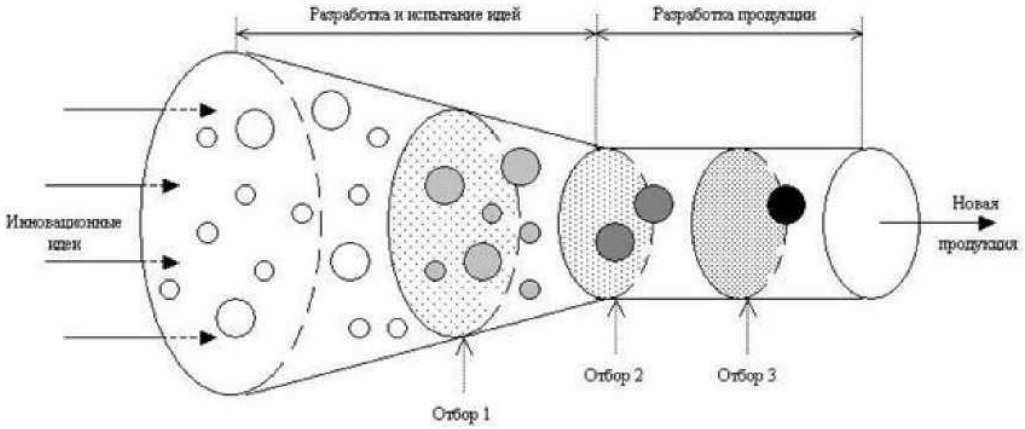

Figure 5. The "Funnel" model presented by Steven Uylwright and Kim Clark

The model shows the process of moving from a large number of ideas to a smaller one the number, but with good prospects for development. The "Funnel" model is inherent mainly in large companies, where various ideas developed as a rule, R&D divisions compete for resources within the firm. The advantage of this modelis to increase innovative ideas and implement them on the market by uniting participants. But in at the same time, an intellectual capital leak is possible [5]. Examples of the implementation of the Funnel model are the innovative activities of the largest in the world the world of the chemical concern BASF Societas Europaea, which brought together the interests of a large number of contractors to implement innovative processes. Currently in order to save material resources, companies are increasingly using information technologies in the implementation of innovative processes. In view of this, the "concept of an innovative information technology model" (G6) was developed (Figure 6) [6].

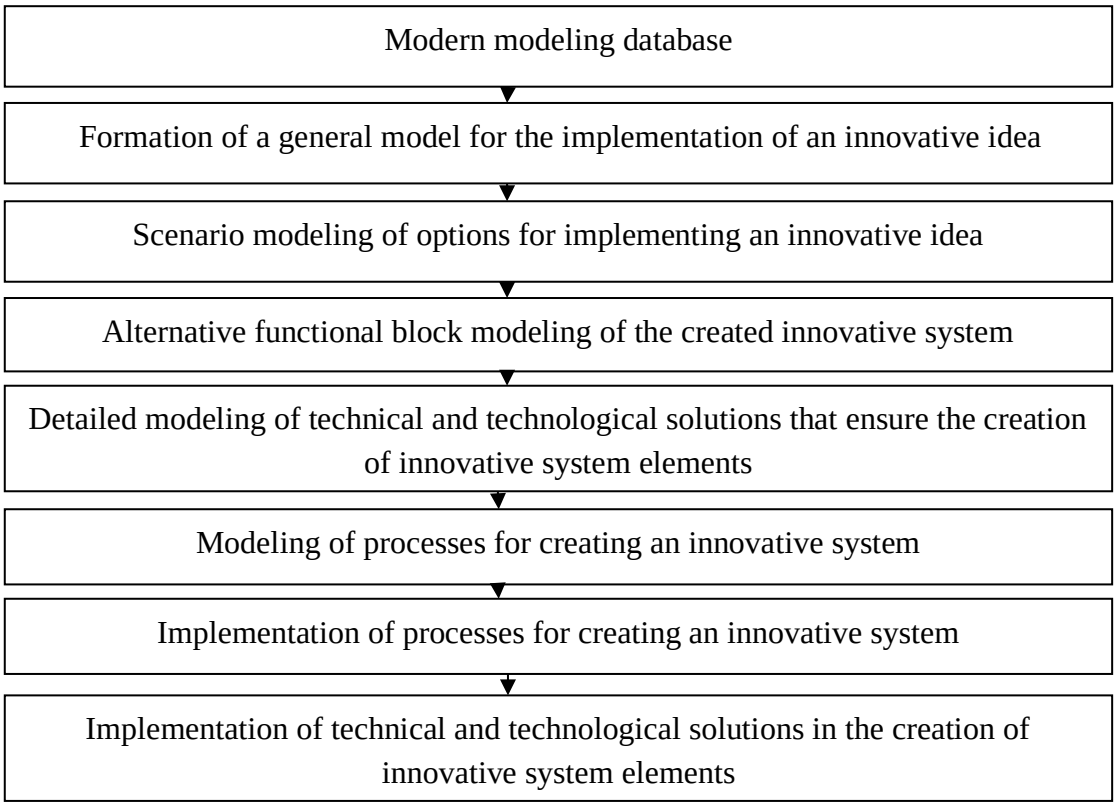

Figure 6. Information technology innovation model concept (G6)

4. Conclusion

The study highlights the significant evolution of innovation models from the initial technology push to the contemporary information technology-driven frameworks. Key findings emphasize the strategic incorporation of digital technologies, enhancing efficiency and market responsiveness across various industrial contexts. This evolution reflects the necessity for businesses to adapt innovative strategies continually to maintain competitiveness in a digitized economy. The study's implications underscore the need for policymakers and business leaders to focus on digital integration within innovation processes to leverage potential growth. Future research should explore the dynamic interplay between emerging digital tools and innovation models to identify new opportunities for sustainable development and competitive advantage.

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