

## EVOLUTIONARY MODELS OF THE INNOVATION PROCESS

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### *Abstract*

*The topic of the evolutionary patterns of the innovation process is of particular importance for the functioning of any company, as it is important to comply with the modern requirements of the environment in the implementation of the founding activity of any enterprise. The purpose of this paper is to present the evolutionary patterns of the innovation process from 1950 to the present, and to determine which generation of the innovation process the modern enterprise should adhere to in its operations. To achieve the given objective, Roy Rothwell's theory, Klein-Rosenberg's chain model, and Chesbrough's model based on open innovation are presented. The expected results of the research are the identification of the place of the modern industrial enterprise among the analyzed generations and the characterization of the innovation process, which should proceed according to the requirements of the defined innovation process model.*

**Keywords:** linear model; nonlinear model; interactive model; Japanese model; knowledge management; innovation imitation

**JEL Codes:** O31, O33, O36

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### **1. Introduction**

There are a number of definitions of innovation in economic science, but none of them can be accepted as uniform. “The definition of the term "innovation" is under constant change and refinement. Today, innovation can mean new and unique applications of old technologies and ways of learning, using design to develop new learning materials, digital programs and services, new processes and structures to improve productivity in different scientific disciplines, organizational creativity and initiatives of the public sector to improve service delivery.” (Yuleva-Chuchulayna, 2022, p. 527). Some of the definitions consider innovation as a product (Kulagin), others as a process (Santo; Massey, Quintas, Wilde, Twist, Cook, Myers), and others as the result of a process (Fathutdinov).

An example of defining innovation as a product is given by Kulagin (2004, p. 58), according to whom innovation is a new or improved product (good, activity, service), a method (technology) of their production or application, an innovation or improvement in the sphere of organization and (or) economy of production, and (or)

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realization of production, providing economic benefit, creating conditions for such benefit or improving consumer properties of production (goods, activities, services).

Innovation as a process is defined by Santo (2004, p. 24). The definition he proposes is the following: innovation, it is such a social, technical, economic process, which through the practical use of ideas and inventions leads to the creation of products, technologies better in their properties, and in this case, if it is oriented to economic benefit, income, manifestation of innovation in the market, can lead to additional income.

Another definition of innovation as a process belongs to Massey, Quintas and Wild (1999). According to them, innovation is a process involving such types of activities as research, design, development and organization of production of a new product, technology or system.

The definitions of innovation as a process proposed by other authors are also worthy of attention, which have the following content: "Innovation is the complete process from ideas to a marketable finished product" (Cook & Myers, 1996).

Also - "Innovation is the process in which an invention or idea acquires economic substance" (Twist, 1989).

Fathutdinov (2008, p. 15) presents innovation as the result of a process. According to him, innovation, it is the final result of the implementation of innovations with the purpose of changes in the object of management and obtaining economic, social, environmental, scientific and technical or other effects.

According to Yuleva-Chuchulaina "innovation is the deployment of concepts or creativity that improve products, processes and procedures by increasing the relevance, utility and effectiveness of an SME's products or services" (Yuleva-Chuchulaina, 2021).

In the next section we will discuss the nature of the innovation process and its evolution as a concept and stages.

## **2. Theories of evolutionary patterns of the innovation process**

Analyzing the definitions of innovation, we can notice that in all of them, regardless of the nature of the innovation (product, process or result of a process), it is expected that after certain actions aimed at creating, changing or improving a product, a positive economic result will result.

Regardless of which of the understandings of the nature of innovation one accepts - product, process or result - the commonality between the different definitions is the final result in economic terms. It must be better than the one before it, if it is an improvement in product or technology, fewer resources must be invested in order to achieve a higher positive financial result from the activity.

In view of the need to carry out a number of actions to achieve the positive economic result, we can define this sequence of actions as a process.

The term 'innovation process' is relatively new. It was first used in the Dictionary of Innovation in 1986 to refer to the sequence of stages in the transformation of an idea into a concrete outcome: perception of a problem or opportunity; first conception of an original idea; research and development; first exit to production and to market; application and implementation; refinement and amendment, bringing revenue (Haustein & Maier, 1986).

The division into distinct stages of the innovation process is characteristic of the scientific and technical field.

According to Panteleyeva (2013, p. 66), the innovation process is regular, relatively continuous and dynamic, oriented towards the introduction of new or the improvement of existing elements. In general, it can be defined as a process of creation and diffusion of innovations, i.e. as a set of sequential and logically related activities that take place from the moment the idea for an innovation is conceived to its market realisation and subsequent diffusion.

Like any scientific theory, the theory of innovation and the innovation process change and evolve over time. In view of changes in the environment and changes in the factors influencing the innovation process, the stages through which an innovation passes in the innovation process vary in number and nature.

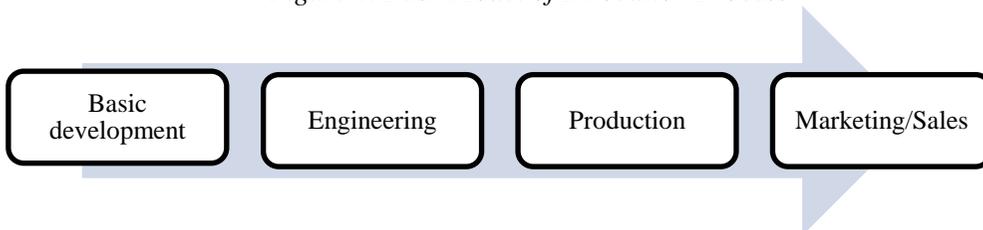
The modern methodology of innovation process research is based on three hypotheses (Ivashtenko et al., 2016):

- "technological impetus" hypothesis;
- hypothesis of "market demand pressure";
- "interactive patterns" hypothesis.

Considering the "technological push" hypothesis in more detail, we will notice the following of a linear model of the innovation process. It shows the successive transformation of ideas into a commercial product through the following stages: fundamental, applied research, development and technological development, marketing, production and, finally, sales.

The so-called Technology - Push model of the innovation process can be visually depicted as follows:

*Figure 1. Push Model of Innovation Process*

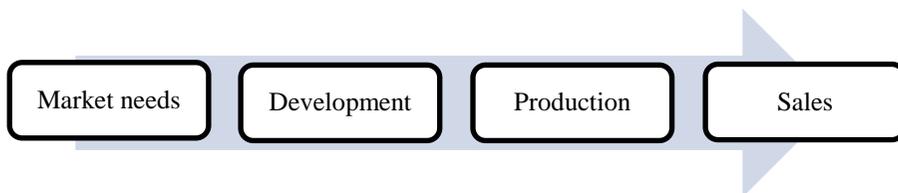


*Source:* Ivashtenko et al., 2016, p. 38

The disadvantage of the linear model is that it does not take into account the influence of the environment. This puts the second hypothesis - market-pull - in a more significant position.

It is based on the pressure on market demand. Schematically presented it looks as follows:

Figure 2. Marketpull Model of Innovation Process

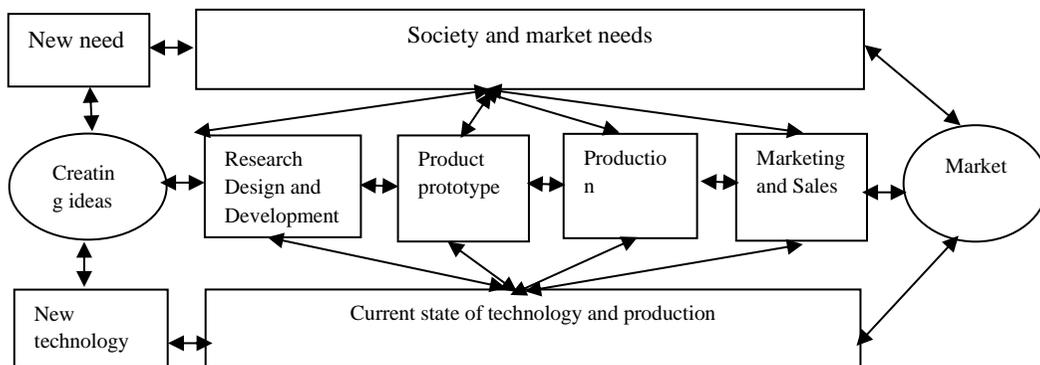


Source: Ivashtenko et al., 2016, p. 39

This hypothesis links the growth of innovation potential to market demand.

Gradually, enterprises have come to the conclusion that an interactive non-linear model is needed that also takes into account market demand and technological development. The interactive model (Coupling Model) looks as follows:

Figure 3. Interactive Model of Innovation Process



Source: Ivashtenko et al., 2016, p. 40

The evolution of innovation process models presented in this way reveals the gradual adaptation to new market conditions, new consumer demands and the path a product has to go through from the generation of an idea to its appearance on the market.

The theory of Roy Rothwell (1994), a British sociologist and economist who has made significant contributions to the theory of innovation, occupies an important place in the academic literature. Taking into account a number of marketing factors,

he presents his model involving five generations (generations) of the innovation process.

If we compare the three hypotheses presented graphically above, we can relate them to Rothwell's five generations of innovation models. He includes the first two generations to the linear approach to define the innovation process. The third generation expresses the relationship between the first two generations and can be correlated to the non-linear approach. The following generations express the interactive model with the presence of linear and non-linear relationships.

The five generations, according to Rothwell, have the following boundaries:

- first generation - 1950s - mid 1960s;
- second generation - late 1960 - early 1970;
- third generation - early 1970 - mid-1980;
- fourth generation - mid-1980 to present;
- fifth generation - present time - future (Hairullin, 2011).

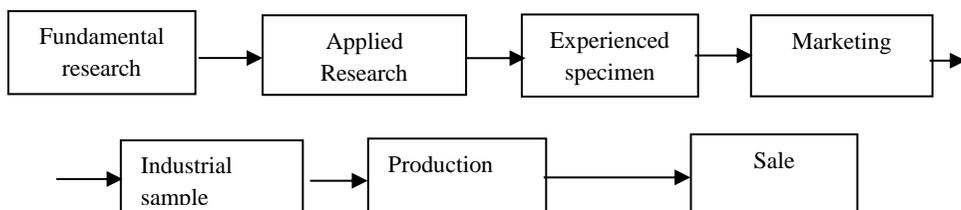
The process of creating and mastering new techniques in the theory of Roy Rothwell (Kovalev & Ulanov, 2010) begins with fundamental research. The second stage of the innovation process, that is applied research works. The third stage involves the implementation of developments at the stage of experimental and design works. At the fourth stage, the process of commercialization of innovations is implemented. The stages involved there are the pre-series production stage and the industrial production stage.

Rothwell's theory is the basis of modern research in the field of innovation process. The fifth generation, which he introduced as an evolutionary stage, expresses the business planning so necessary for any company. Looking into the future through strategic planning and formulating strategic goals adds further certainty to the process of realising an innovation idea.

Dzhuha (2016), in his textbook on Innovation Management, presents the five generations of the innovation process as a sequence of stages, which will be schematically presented below.

The author illustrates the first stage, the Technology Push Model, in the following way (Fig. 4):

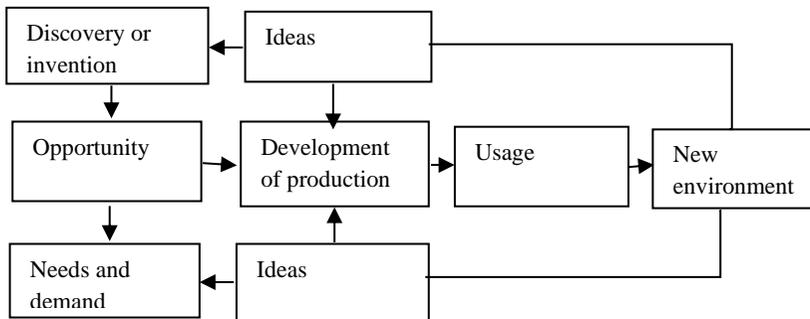
*Figure 4. First Generation of Innovation Process*



Source: Dzhuha, 2016

The second stage, which is also a linear model, the author calls Need pull Model (Fig. 5):

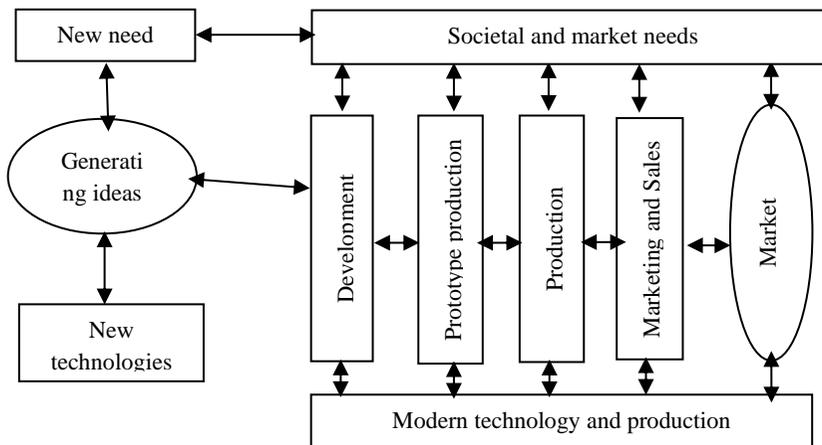
*Figure 5. Second Generation of Innovation Process*



Source: Dzhuha, 2016

The author calls the third stage or the so-called third generation innovation process the Coupling Model. It is a combination of the first and the second model. Depicted graphically it looks like this (Fig. 6):

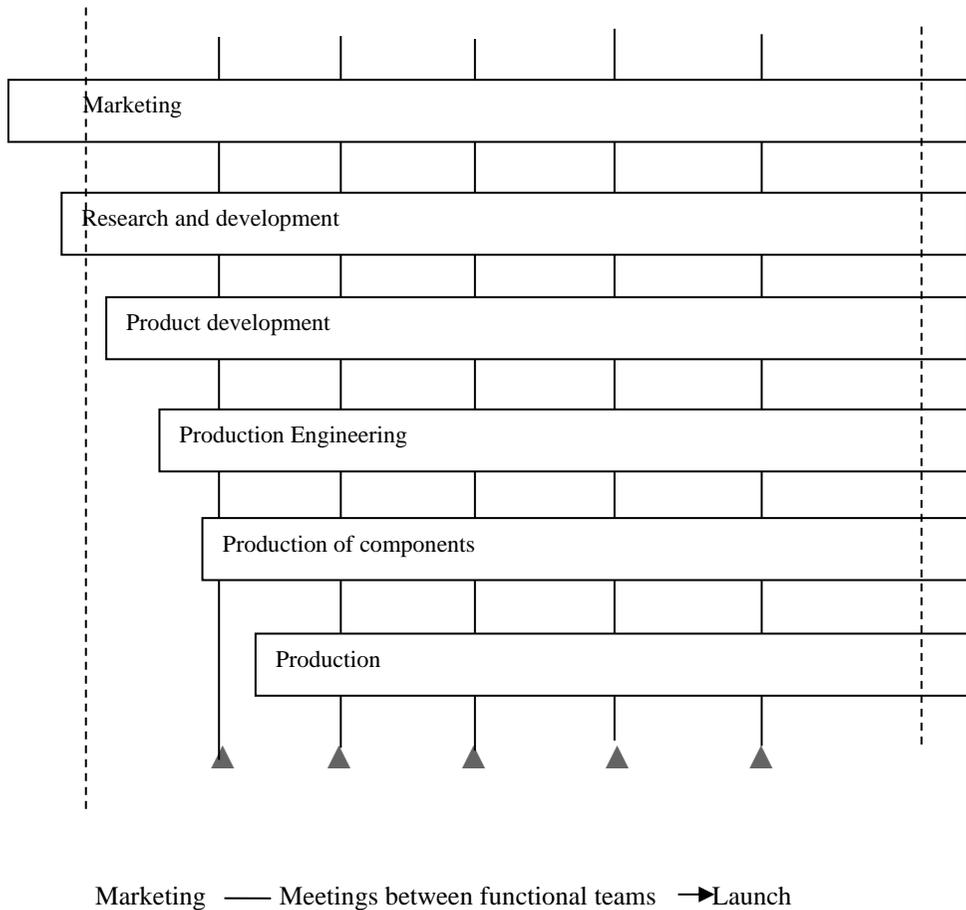
*Figure 6. Third Generation of Innovation Process*



Source: Dzhuha, 2016

The fourth stage (fourth generation innovation process) is known as the Japanese model. It is distinguished by the simultaneous action by the integrated groups and the presence of external horizontal and vertical linkages. It can be represented graphically as follows (Fig. 7):

Figure 7. Fourth Generation of Innovation Process



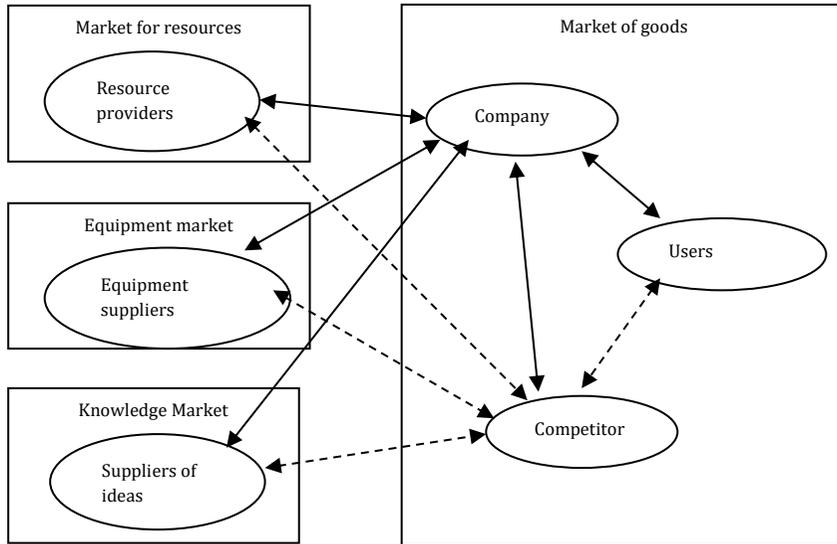
Source: Dzhuha, 2016

The fifth stage (fifth generation of the innovation process) covers, as already mentioned, present and future time. Also known as the Strategic Networking Model. In this model, R&D activities are introduced through the application of latest computer technologies, simulation modeling, automated design, expert systems, and integrated agile manufacturing systems (Dzhuha, 2016). A graphical representation of the fifth generation can be seen in figure 8.

Analyzing Rothwell's theoretical models, we again observe the interference of encroaching novelties. The first models, linear and non-linear, are relatively simplistic, while in the subsequent models, especially in the Fifth Generation of the innovation process, a link is made between the goods market and the markets for resources, equipment and knowledge. In order to interact between the goods market

and the other markets, there must be suppliers of resources, equipment and ideas respectively.

*Figure 8. Fifth Generation of Innovation Process*



Source: Dzhuha, 2016

In turn, the goods market can be seen as interacting elements that include the company that enters the goods market, consumers and competitors. The important role of small business is that it is flexible enough, provides a significant number of new jobs, saturates the market with new goods and services, satisfies the numerous needs of enterprises, produces special goods and services, has economic freedom and is innovative.

Of interest is the systematization of Burmenko and Pochomchikova (2014). The following table systematizes the innovation process design models according to these authors:

*Table 1. Evolution of innovation process models*

Time parameter	Conceptual parameter
1930 – 1960	Model Technology Push
1960 – 1970	Model Market pull
1970 – present days	Collaborative model 1+2
1980 – present days	Chain model Klein - Rosenberg
1990 – present days	Model of integrated networks and circuits
2000 – present days	Chesbrough model based on open innovation

Source: Compiled by the author based on material from Burmenko &Pochomchikova, 2014

The new distinct models of the innovation process in the table above, this is the Klein-Rosenberg model, which expresses the inability of linear models to reflect innovation processes comprehensively. C. Klein and N. Rosenberg first paid attention to knowledge management.

According to the model of integrated networks and chains, in the context of limited resources, it is important not only to work on strengthening within the enterprise, but also on creating network interaction in the external environment.

The open innovation model is associated with the concept of 'imitation innovation'. In contrast to Rothwell's theory, which we have examined in detail, we also notice here a 'sixth generation', which the American scholar Henry Chesbrough developed as a concept.

According to him, open innovation is "the purposeful use of knowledge inflows and outflows to accelerate internal innovation, and expand markets for internal use. Open innovation is a paradigm that suggests that enterprises can and should use external and internal ideas, and internal and external pathways to market" (Manolov, 2016).

Following the evolutionary models of the innovation process thus presented by various researchers, we will propose a model of the innovation process that is suitable for the industrial enterprise today based on the theoretical basis.

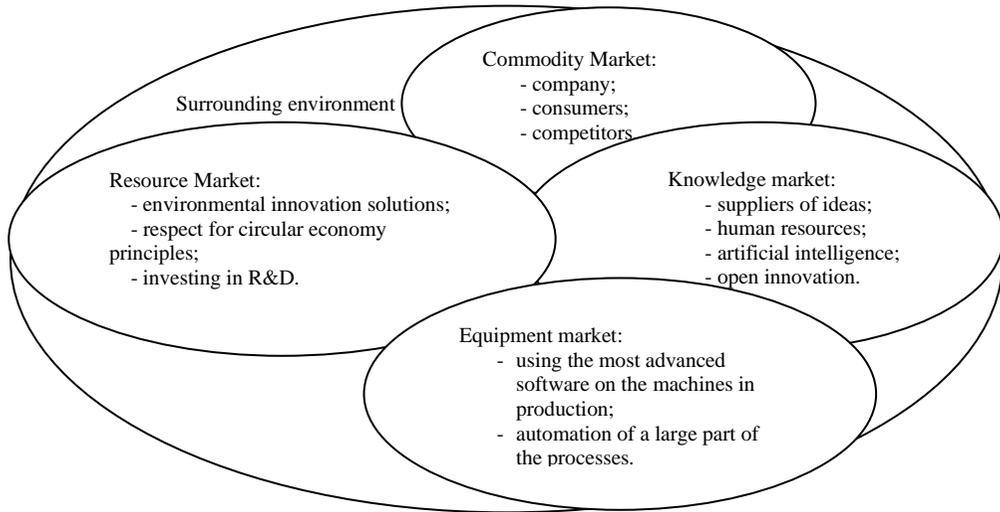
### **3. The innovation process in the industrial enterprise**

Based on the analyzed innovation process models, we can design a model applicable in the industrial enterprise. For this purpose, it is important to characterize the industrial enterprise in order to be able to trace how its activity proceeds and to determine what are the differences between the industrial enterprise and the commercial enterprise offering goods or services. In other words, what are the characteristics of the production process in relation to innovation compared with the innovation process in a company that trades in goods or services.

It is important to take into account the technological advances of today and to take into account the development of business processes.

In relation to the innovation process and the activities that take place in the enterprise, the model we propose contains elements of the models presented above, corresponding to fourth and fifth generation innovation, combined with new elements belonging to the sixth generation, proposed by the American scientist Chesbrough.

Figure 9. The innovation process in the modern industrial enterprise



Source: Compiled by the author

As a clarification to the above figure, we can summarize that in our opinion, the appropriate innovation process model will necessarily include all resources and equipment that, through their use, will be environmentally friendly; it is of particular importance to apply state-of-the-art technologies in technical and software activities. It is also important that the human resources employed carry out their activities in conjunction with the capabilities of artificial intelligence and open innovation by building networks of partnerships with scientific institutions and leading business partners that contribute to the vertical development of the industrial enterprise. Sufficient resources should also be invested in research and development to ensure the most efficient production of the highest quality.

## Conclusion and Recommendations

After presenting the main theories of the evolutionary models of the innovation process, it becomes clear that from the 1950s to the present day the theory of the innovation process and its models have undergone a number of changes. The transition from a linear to a non-linear approach, then to an interactive approach and to an integrated approach is due to changes in the factors that influence the innovation process.

We can conclude that regardless of how we perceive innovation as an entity - product, process or outcome, the commonality between the different definitions is the final outcome in economic terms. It must be better than what preceded it, if it is an improvement in product or technology, and it must also aim to achieve a positive financial result from the company's activities by using fewer resources.

The next conclusion is that in each of the theories of evolutionary models of the innovation process considered, a positive economic result is expected to follow specific actions aimed at creating, changing or improving a product.

The presented theories according to their time span can be distinguished as different generations of the innovation process.

Nowadays, enterprises in industry have to combine as stages of their innovation process the characteristic of the fourth, fifth and even sixth generations. It is important for the enterprise to strive to update its resources, equipment, knowledge and goods according to the modern and constantly changing requirements of its environment.

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