

# Past, Present and Future of the Innovation Process

Review paper

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**Abstract** In the modern globalized world, innovation is a basic prerequisite for economic development and the preservation of competitiveness. However, there is still no generally accepted definition of innovation or the innovation process; individual authors use their own definitions, often formed from different concepts. This paper compares these definitions using methods of analysis and synthesis, constructing its own conceptual framework of the innovation process reflecting the key characteristics that are identical or similar in many of the compared definitions. When constructing a new definition and model, it is necessary to bear in mind that innovation is not an isolated activity but rather an entire process or even sequence of processes. With true innovation, every partial process must be successfully completed. This process as a whole becomes the starting point for further research, measurement and the management control of innovation performance under the postdoc research project "Innovation Process Performance Assessment: a Management Control System Approach in the Czech Small and Medium-sized Enterprises" No. 13-20123P of the Czech Science Foundation.

**Keywords** Innovation, Innovation Process, Conceptual Framework, Model, Development

## 1. Introduction

Innovation has always played a key role in economics. However, the field of science changed significantly at the beginning of the 20<sup>th</sup> century, bringing forth a rapid development of technology. Key discoveries in theoretical and nuclear physics, organic chemistry, biotechnology, telecommunications and cybernetics were made during that time. In the past decade, the role of innovation has changed substantially, again. The first Boeing 747 took off in 1969 and is still the main aircraft carrying passengers over the oceans. Cars on the motorway still go at around 130 km/h; they have lower fuel consumption and are safer, but the rate of their evolution is incomparable to 100 years ago. Nowadays, it is more about the creative process, generating new ideas, or information and knowledge - these drive innovation and development. A good example of such development is the IT sector, which is accelerating at an incredible speed. The first mobile phones from thirty years ago were as large as a brick. Six years ago, they were much smaller but they were still just phones. Now, a mobile works as a camera, a receiver, a TV, a navigation aid, a credit card and even a medical diagnostic device.

These new phenomena are often described as a manifestation of the oncoming information society, a new knowledge economy [e.g., 1-5]. The generally accepted key aspects of an information society, or this new economy, include the widespread and efficient use of information and communication technologies. The efficient use of new technologies relates to innovation in all disciplines, fields and activities of both economic and social life, as well as to the prominent position of information and knowledge in the development of economics and society. New concepts are leading now: dynamics, flexibility, change and responsibility [6].

## 2. Material, methods and objective

The objective of this paper is to describe the development of innovation from the moment when this expression first appeared and was introduced to science and everyday life, and compare the individual approaches and models of the innovation process published by leading experts in both the past and in recent years. The contribution of this paper is the systemization of various perspectives, viewing the content of the term 'innovation process', and their synthesis within a new conceptual model of innovation. It is meant to serve as an inspiration for enterprises that stand at the beginning of this process. In addition, it is also important in terms of innovation management, which is a field of science, and related disciplines, especially strategic management.

The systems approach is applied and several scientific methods are utilized, including analysis, synthesis, comparison and modelling:

- Analysis was used as a method of acquiring new knowledge and for its interpretation. When processing secondary data, the secondary analysis method was used. The professional literature, and particularly foreign resources, provided a source of secondary data.
- Comparison and synthesis was especially used when the conceptual model of innovation was designed.
- Modelling was used during the development of a conceptual model of the innovation process.

## 3. Results

There are numerous definitions and concepts of 'innovation' extant in both economic and business theory and in practice as well. Innovation is likely to be classified according to various criteria. In the context of history and its importance, two of the most basic concepts – Schumpeter's and Rothwell's - are presented in the analytical part of this paper, since both have made significant contributions to the understanding of innovation management. These concepts become an

initial point for the design of a conceptual innovation process framework.

### 3.1 Schumpeter's concept

The term 'innovation' appeared at the beginning of the 20<sup>th</sup> century and it was intensively studied by Austrian economist Joseph A. Schumpeter, who was then followed by many other experts. He proposed five types of innovation:

- The introduction of new products.
- The introduction of new methods of production.
- The opening of new markets.
- The development of new sources of supply for raw materials or other inputs.
- The creation of new market structures in an industry [7].

Schumpeter understood innovation very broadly as a product, a process and as organizational changes which do not have to arise from new scientific discoveries, but which may combine already existing technologies or their applications in a new context. These are understood more generally and broadly than scientific and technological progress, and they do not include just technical and technological changes or improvements, but also practical applications. In his theory, Schumpeter distinguishes between a mere producer and an entrepreneur. An entrepreneur is a producer or tradesman introducing so-called 'new combinations' (the earliest name for innovation), which bring profit to a business exceeding the normal or average profit achieved by normal passive producers and traders. **Innovation is, therefore, a kind of creative act in economics, requiring a business attitude.** Schumpeter notes that such profit can be achieved and maintained, in the long term, only by those business people who are able to repeatedly create or realize new innovations.

His concept of innovation became a basis for numerous studies and modern concepts in innovation [such as 8 and 9].

### 3.2 Rothwell's generation concept

One of the leading authors who has contributed to the historic analysis of developing innovation process models is Roy Rothwell [10], [11]. The conceptual framework of the innovation process will be described from his perspective, using his division according to generations. Rothwell distinguishes between five generations of the innovation process model. However, it is important to stress that progress from one model to another does not mean that the previous model is completely abandoned and replaced. Models can issue from each other or can be linked, while transition from one generation to another is the result of changing attitudes. Determining which

innovation process is the final correct one depends on the type of industry and innovation. With this, Rothwell explains that the sequence of generations is not a hierarchy of better and better-used models.

### 3.2.1 1st generation – the technology push model

The division of the innovation process into phases is not a new phenomenon and has been made since at least the 1950s. The linear **Technology Push Model** became widely used until end of 1960s. During these years of post-war economic growth, companies focused on building production capacity and research and development. The market was simply a place that captured the fruits of research and development – people bought what was currently on offer [10].

Innovation was understood as a linear process, with research, development and the outputs of new successful products standing on the same level [12]. The chronological alignment of each phase, from elementary research, the preparatory phase of production, production, marketing and final sale is shown on Figure 1.

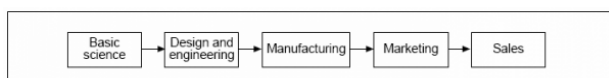


Figure 1. The linear technology push model [11]

A good example of a successful linear technology push model is laser technology. Lasers were intensively researched in the 1950s as their theoretical background was developed from the knowledge of Einstein, Planck and Bohr. In 1960, the first laser device was successfully built by Maiman in California, and laser technology found applications in many fields. Today, lasers are used for cutting, boring and welding materials, and they have also revolutionized measurement, medical and information technologies [13].

### 3.2.2 2nd generation – the market pull model

The 1960s through to the mid-1970s were characterized by relative wealth and changed market conditions. Thanks to increased competition and diversification, it became important to include the customer’s needs in the innovation process, and thus also in marketing [14].

This led to the formation of a new model pulled by the market and its needs, which was still represented by a linear organization of the individual phases, as in the previous generation – the **Market Pull Model**.

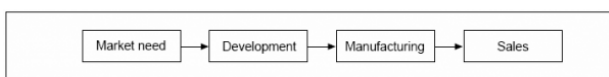


Figure 2. The linear model pulled by market needs [11]

The understanding of the process and the concept of innovation changed to include what was seen as a result of perceived – and sometimes of accurately expressed – customers’ needs, sourced through market research. The needs and demands of the market determined the work of research and development departments in companies [10].

Many companies achieved only incremental innovation; therefore, it was not possible to react to market shifts [12].

### 3.2.3 3rd generation – The coupling of R&D and marketing (the interactive model)

In the 1970s, as a result of the economic crisis following World War II, inflation, saturation of the market and high offer capacities shifted trends towards rationalization, consolidation, control and cost reduction. It was clear that neither technological push nor market pull strategies were enough to successfully handle the innovation process [12]. The further detailing of the phases and the implementation of feedback steps were needed.

A new generally accepted model, adapted in the mid-1970s, combined the technology push and market pull models. It was improved with feedback and called the **Interactive model** of technological opportunities and the needs of the market. Rothwell saw the offer, as well as the market, as an impulse for the innovation process [11]. Research, development and marketing functions worked equally under these models.

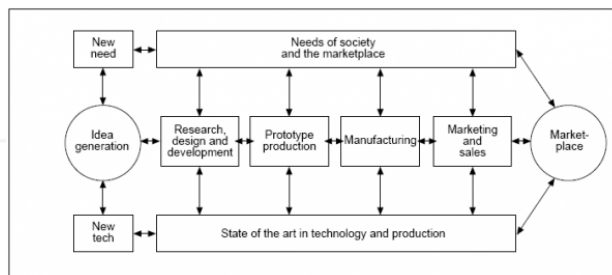


Figure 3. The interactive phase model [11]

### 3.2.4 4th generation – the integrated business processes model

This generation was characterized by the parallel use of integrated research teams, and the involvement of the supplier and important customers. It clearly stands out from the third generation and models a stronger parallel process of innovation. Cooperation between research, development and production is enhanced, and horizontal collaboration, regardless of the company’s boundaries, is also considered [15].

Due to the constantly shortening product lifecycle, this period is characterized by a time-based strategy. Due to the necessary shortening of innovation time, process

innovation is seen as a parallel process instead of as a sequenced process. External sources of ideas and thoughts become more important, and the innovation process integrates external resources as well as the activities of different internal departments. This leads to the overlap of various functions and tasks, but mainly to substantial time savings compared with the previous sequence processes [10].

The fourth generation covers the so-called **Integrated (Chained) Model** by Kline and Rosenberg [15], which represents a further step towards a comprehensive innovation process actively involving research and existing knowledge. This model demonstrates the necessity of integrating knowledge into the innovation process, because knowledge is not understood as a result of scientific activities, but rather as a result of interaction between the individual units of a company, the company itself and its environment.

The division of this model is not very innovative. It is new in the fact that the market represents both the beginning and the end of the innovation process. Knowledge is integrated in all phases of the innovation process (mainly in the research phase) and, therefore, considered as a necessary prerequisite for innovation. The market and the consumer are perceived in the same way [15].

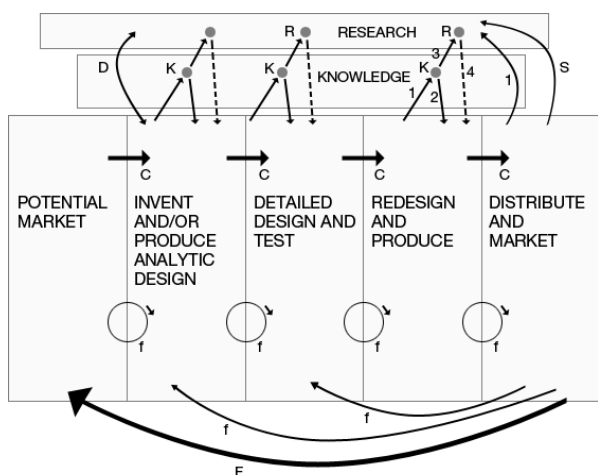


Figure 4. The integrated chained model [15]

### 3.2.5 5th generation – system integration and networking

Strategic trends from the fourth generation have been preserved in an intensive and improved form with a stronger focus on quality and performance. Thanks to the constant growth of competition, the shortening of the product lifecycle and the sharp technological turn, the importance of a time-based strategy was adapted from the fourth generation. Although it was not necessarily important to be the leading company with innovations on the market, being the one that offered a product in a short

time represented a certain competitive advantage [11]. It is also necessary to consider how the reduction of the time left for research and development led to increased costs. This relationship was presented by Gupta, Brockhoff and Weisenfeld [16] in Figure 5, showing the relationship between the development time and research costs. If the research period is reduced to below the minimum of a function (to the left along the curve), cost increases upon additional expenses for coordination. A similar effect applies to the extended development time over the maximum of the function (to the right along the curve). Additional costs also arise, especially with decreasing motivation and increased variable costs (e.g., additional working time). Thanks to measures aimed at increasing the efficiency of the innovation process, it is now possible to move from a higher to a lower time/cost curve. This kind of parallel shift of the curve represents development cost reductions, while preserving the same time needed for development and the same costs for research. The minimum of the new function lies at the point of low cost of research and the short time necessary for development.

The following measures to increase efficiency are needed in the fifth generation: i) system integration with inner organization, ii) extensive networking, iii) flexible and flat organizational structures, iv) mature inner data bases, and v) electronically supported product development. The Internet is the main driver expanding the boundaries of research and development activities in companies, facilitating integration with the company environment (competitors, traders, customers, suppliers, etc.) [11].

The innovation process of the fifth generation is characterized by Rothwell [11] as the **System Integration and Networking Model (SIN model)**. It extends the parallel development of the fourth generation with the integration of IT methods, such as simulated studies and expert systems. Collaboration with external research facilities and co-operation in the marketing area are much stronger than in the fourth generation. These advanced strategic partnerships were set up along with collaborative marketing and research arrangements, such as 'open innovation'. This model also emphasizes the vertical linkages with suppliers and customers along the whole innovation process (e.g., suppliers are involved in the co-development of new products and/or share the technical systems used for it), and the horizontal linkages take place in a variety of forms (joint ventures, alliances, consortia, etc.).

The fifth generation also represents an intensive transition to electronic means – advanced companies use IT methods (such as computer-aided design) to support and speed up the innovation process.

Figure 5 shows the relation with Rothwell's description of the last three generations, where each generation

represents an efficiency increase, especially in terms of reduced costs when compared to the previous generation.

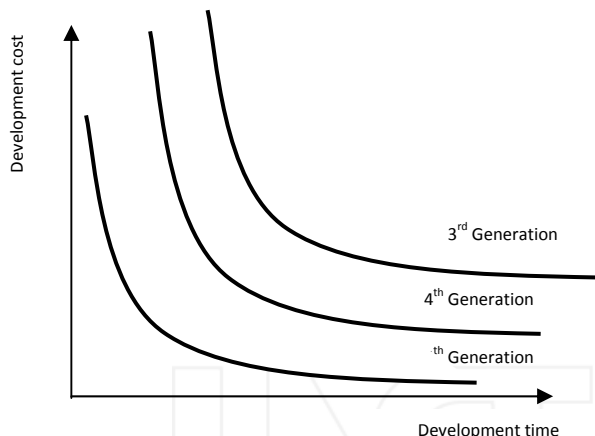


Figure 5. Cost reduction curve [11]

#### 4. Discussion

Successful innovations are the results of a series of management, marketing, scientific, technological, organizational, financial, business and other types of activities. Market participants act together with employees, technologies and environmental influences, all of them acting dynamically and independently. This characterizes a complex system.

It is expected that companies will aim at two goals in relation to continuously performed efficient innovation: *“To ensure [the] long-term efficient development and growth of the company with parallel continuous elimination or at least [the] mitigation of inefficiencies in its business processes”* [17].

The innovation process must be a key process in a company, since innovation provides sustainable market success. Well-managed and successfully-introduced innovation into the market represents a tool for companies, by means of which they can achieve competitive advantages and enable their long-term prosperity. Therefore, it is one of the key strategic success factors. Companies that do not innovate die [e.g., 4, 18, 19, 20]

Nevertheless, successful innovations do not grow out of simply copying, but upon surpassing competitors with different approaches to a problem and with differentiation. It is necessary to bear in mind that innovation must generate value for the customer as well as for the shareholders and employees of the company. Leading Czech authors [e.g., 21, 22] believe that it will be necessary to divide a company into two parts:

- A part that creates new products (development, technology construction, design), produces them and supplies them to customers.

- A part that constantly improves its products, processes, business systems, innovation methods and the thinking of the people in the company.

Innovation can be a complicated process. To be able to think about innovation clearly, it is better to divide it into two elementary parts [28, 30]: **invention**, which relates to the original idea, notion or concept. The second part of innovation process, **innovation**, creating the invention and introducing it to the market.

Consequently, these parts are divided into six individual phases (see Figure 6). The following characteristics of the innovation process were drawn from the Czech and foreign professional literature [10, 11, 18-30].

#### Phase 1

The starting line for new ideas and innovative designs is the **studying and monitoring** of the internal and external environments of the company. This initial phase of the entire innovation process should be driven by competitive pressure and the effort to investigate new possibilities – to invent something new. A company must be able to recognize and process the signals of potential innovations. Upon this strategic view, it is then necessary to consider and compare the pros and cons of these signals. These activities must run in parallel so as to eliminate ideas lacking innovative potential and also to prevent the refusal of new ideas simply based on the fact that they are new. This phase results in a strategic decision regarding which innovative idea the company should develop and support.

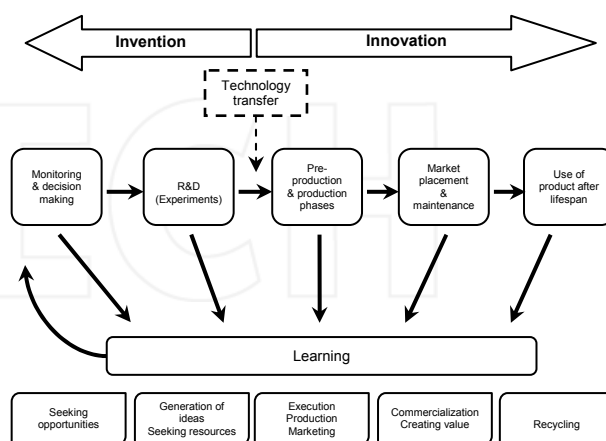


Figure 6. Design of an innovation process model

#### Phase 2

The second phase of the innovation process, **applied R&D**, carries the hidden potential of a new idea through different stages of development to the final version of something new. It does not necessarily have to involve extensive R&D or the search for the correct sources, but can also be something as simple as buying a commonly-

available product or technology licence. It requires the sourcing of related knowledge and know-how. This phase should involve testing the feasibility of new ideas in a given company, in a given time and for a given market. This is illustrated by prototypes and demonstration models. It is necessary to define who the consumers are and what they will use the new product or service for. This may lead to the discovery that an idea is good but that it may be either ahead of its time or else not suitable for the given market. In such a case, it does not have to be regarded as an innovation failure; the new idea may become a catalyst facilitating the birth of some other new innovation.

The transistor, first presented by Bell Labs in 1948, was first mentioned only on the back of newspapers and trade journals. However, this invention completely transformed the second half of the 20<sup>th</sup> century and shaped the development of 21<sup>st</sup> century industry. Today, large numbers of these components are contained in microchips as essential parts of computers, the Internet, mobile phones, digital cameras, and many other everyday items used by people all over the world.

Another example of an 'unsuccessful' innovation is the post-it pad. In 1968, Spencer Silver was working for an American laboratory for the 3M corporation. He invented glue that seemed totally useless – it did not stick permanently, was much weaker than the adhesives already produced by 3M, and it came in tiny drops instead of a film. However, Silver sent samples to his colleagues hoping that someone would find a use for his invention. The non-stick glue finally found its purpose some years later. Art Fry, Silver's colleague, was a singer in a church choir. He was looking for a note that would not slip from a tilted songbook, would not damage the pages and could be moved easily. He remembered Silver's glue and started producing the first notes coated with this glue in 1974. The result was satisfactory. The note held to paper and other materials, but it was easily peeled off, did not leave marks and was reusable. A product with unexpected potential was born.

#### Phase 3

The described experimenting also reaches the next phase of the innovation process – the **pre-production and production phase**. This represents an imaginary thread linking knowledge and the final innovated product. Companies often implement innovation projects in conditions of uncertainty (we do not know the exact form of the final innovation or whether the market will accept it, etc.). These uncertainties are gradually replaced with concrete findings and knowledge. Innovations rarely relate to a single technology or a single market, but cover

a number of different pieces of knowledge. Activities related to market preparation and marketing activities promoting the new product must take place alongside the resolution of technical problems. The company must eliminate uncertainty – although the final product is technically excellent, there is no guarantee that customers will accept it. The output is an innovative product and a market ready for the final launch of the innovation. The phase of applied R&D with the production phase is one of the longest and most expensive parts of the innovation process. As such, we must not forget the previous activities, i.e., generating ideas and searching for resources (especially finance, communication, strategies, goals and assistance). Improvement in these activities can significantly shorten the time from the discovery of an opportunity to the launching of an innovation on the market. It can also generate a product that will react to the market's needs much more efficiently.

#### Phase 4

Innovation is a process starting with an idea or the imagination and followed by various stages of development, issuing with **implementation**. Without the launch of the innovation on the market, the implementation process is not complete and the innovation cannot be considered to be implemented. This phase represents the launching of the innovation on the market, the management of its initial acceptance and sustaining its long-term acceptance and use by the market. All of these activities are supported by information-gathering from various sources as to whether the innovation solves the customers' problems or yields new uses. The key feature is marketing activity and promotion using this acquired information or the product design, etc., with the aim of minimizing the adverse attitudes of market participants towards the innovation. During the initial phases after the innovation successfully enters the target market, the company may rely on competitive advantages based on the superior quality of the offered product. When the product breaks through to the market and starts being profitable, it is necessary to look further ahead and protect the positions already occupied. The further development of the innovation should follow after the market launch.

#### Phase 5

Every company needs people, materials, technologies and energy. The effort to accelerate economic growth is often in conflict with **environmental protection** and the conservation of resources and the quality of nature and the landscape. Attention that is given to technical, security and environmental requirements will pay a firm back when compared to losses due to production limitations, penalties or other sanctions relating to breaching environmental laws or regulations. As time has gone on, products have been getting much safer, and

companies are becoming more aware of their own responsibility for the protection of the environment. More and more companies are certified for environmental management systems according to ISO 14001.

#### Phase 6

The feedback phase of **learning** reflects whether the previous phases and analyses achieved success or failure. It is necessary to analyse deviations from the expected costs, term changes and their causes, and to assign responsibility to those things that caused them. The aim is to learn how to better cope with the innovation process and thus build knowledge upon any gained experience. This last phase faces many problems. Instead of learning and gaining experience from the previous innovation project, it is quite common for the individual participants to blame each other and try to cover their own errors. Efficient 'learning' requires a willingness to perform open and informed revision. Another problem closely relates to the process of 'un-learning'. Gaining new knowledge is important, but one must also learn to forget old ideas. Benjamin Franklin once said: "*We must learn to forget what we learned.*" Indeed, when it comes to innovation activities, this quote rings absolutely true.

While the entire innovation process is described as being linear, it moves in non-linear cycles and must take place along the spiral of the long-term growth of a company [31]. Understanding a defined innovation process as such will enable the clearer definition of any tasks that must be continuously performed and their mutual linking (e.g., what must be done first and what comes next). The improvement of the innovation process includes the increasing of individual steps' efficiency, changing the sequence of steps or the identification and removal of unnecessary steps.

#### 5. Future research

The central contribution of this paper was the development of a conceptual model of the innovation process. Research into individual approaches to measuring and managing innovation processes' performance in Czech SMEs serves as the objective of the postdoc research project of the Czech Science Foundation no. 13-20123P. The substance of this project is to design the basic criteria and metrics, and to further develop the management control system approach to the assessment of innovation performance in the Czech SMEs. Future research should collect, where possible, objective quantitative and semi-qualitative data on the current state of the issue under investigation.

The research focuses on Czech SMEs, since they are key drivers of the Czech economy. They provide around two million jobs, generate more than 36% of Czech Gross

Domestic Product, and represent more than 99% of all Czech enterprises [32].

Their effectiveness must be assessed by economic criteria at all stages of the innovation process, from the birth of an idea to the final commercialization stage. Research outcomes will help resolve the problem of an empirical assessment of the importance of individual variables in the determination of future earnings, and will propose measures for the improvement of innovation performance assessment with the use of advanced mathematical methods and models. In this country, this type of approach is missing and there remains a large gap in the assessment of innovation processes' performance.

#### 6. Conclusion

This article summarizes the development of the understanding of the innovation process by leading experts from the 20<sup>th</sup> century. Schumpeter's definition of innovation went through different stages of development, from simple linear models to interlinked models and on to the current network models of mutual collaboration between companies. Companies create innovation networks and thus significantly reinforce their competitive positions. As the new approaches of large brands (e.g., P&G, BMW, Apple, IBM and GE) show, real life situations break the boundaries surrounding a company, enabling open cooperation with external partners in order to expand innovative activity outside the walls of company laboratories and design studios, allowing it to focus more on the surrounding environment (i.e., on customers, other development facilities, universities and other companies, including competitors. This significantly shifts the 20<sup>th</sup> century innovation paradigm characterized by a closed approach based on control within a single company.

The economics of the 21<sup>st</sup> century will be characterized by knowledge, information and innovation (e.g., [1-5]). It will be based on knowledge, experience, creative work and qualification. A crucial role will be played by education, research and development. We are currently experiencing a change from the industrial-based paradigm to a knowledge-based one, and it is necessary to abandon the linear model of innovation processes and begin understanding it as continuum (e.g., [2, 18, 22, 33]).

#### 7. Acknowledgments

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