Journal of
Value Creating in Business Management
https://www.jvcbm.ir

Volume 4, Issue 4, Winter 2024, Pages 71 to 96

Original Article (Mixed)

eISSN: 2980-8359

Evaluating the level of digitalization of the innovation process with artificial intelligence approach in the digital transformation of knowledge-based companies

Ali Bagheri[1], Reza Radfar[1], Sepehr Ghazinoory[2]

1- Department of technology management, management faculty science and research branch of Islamic azad university
2- Department of Information Technology Management, Faculty of Management, Tarbiat Modares University Tehran Iran

Receive:
10 July 2024
Revise:
11 September 2024
Accept:
13 October 2024

Keywords:
digital innovation, adaptive neural fuzzy inference system (ANFIS), digital transformation, technology-based companies (TBFs), innovation process, digitization, artificial intelligence

Abstract
The purpose of this research is to design a model to evaluate the level of digitization of the innovation process centered on artificial intelligence in knowledge-based companies, so that the digital maturity of the innovation process in an organization can be measured. The results of 188 indicators were distributed in the form of a 5-point Likert questionnaire and by Delphi method in two times among 18 experts in this field. The result of the work was 5 components as input to the model, which was sent in the form of a questionnaire to 230 knowledge-based companies of Pardis Technology Park. 198 companies completed it and sent it back. From this number of samples, 150 data were separated for training data and 48 data as model test based on a random function. In the last stage, i.e. modeling, the adaptive neural-fuzzy inference method was used for the model. The method of grid separation or lookup table (PG) in MATLAB 2023 software was used to evaluate the performance of the model using root mean square, error (RMSE) and relative error (E). This research was able to provide an intelligent model with a very low error. As a result, it was able to achieve effective indicators in the degree of digitization of the innovation process.

Please cite this article as (APA): Bagheri, A. , radfar, R. and ghazinoory, S. (2025). Evaluating the level of digitalization of the innovation process with artificial intelligence approach in the digital transformation of knowledge-based companies. *Journal of value creating in Business Management, 4*(4), 71-96.

https://doi.org/10.22034/jvcbm.2024.472784.1420

Publisher: Research Center of Resources Management Studies and knowledge-based Business

Corresponding Author: Reza Radfar

Email: ifchlg@gmail.com

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Value Creating in Business Management
https://www.jvcbm.ir
Volume 4, Issue 4, Winter 2024, Pages 71 to 96

Extended Abstract

Introduction

An innovation process, whether in its general form from the stage of idea formation to the stage of entering the market and commercialization, or in each of the parts separately, must be in such a way that it has the most productivity (efficiency and effectiveness combined during the process). Moving in this direction reduces financial, time and human costs. The relevance of innovation to ensure the competitiveness of companies has been confirmed among researchers and professionals (Schiuma, 2012). Also, innovation is a risky process that requires resources, competence, culture and attitudes that cannot even be promoted and managed easily (D'Este et al., 2012). Due to the mismatch in digital skills and awareness, employees are not able to understand the reasons and potential of implementing new technology and displacement. Therefore, the next challenge in the digital ecosystem is to promote and define conditions, roadmaps and management models for implementing digital innovation strategies, for managing digital knowledge and fostering continuous innovation (Nonaka & Takeuch, 2019). Innovation processes rely on external institutions, i.e. innovation intermediaries, research and development laboratories, or innovation centers (Corre & Mischke, 2005). Global and virtual competition, as well as the rapid development of digital technologies and solutions, raise efficiency standards, increase the speed of market dynamics, and reduce product life cycles (Schiuma, 2012). Each actor involved in innovation must be aware of the organization's vision, goals, and strategies in order to effectively contribute and generate value (Lianto et al., 2018; Nonaka & Takeuchi, 2019). To understand and effectively manage technology, codification and exploitation of generated knowledge, specialized skills and new governance models are required (Joshi et al., 2010).

Theoretical framework

Digital innovation process

Completely rebuilding business around new opportunities and new demands is possible through digital technology. Eyring et al., (2022) in an article, mentioned these processes under the title of digitization. Digitization is a useful and effective necessity. It provides a vision of digital assets that offer opportunities to business or even to industry. Digitization sometimes reconceptualizes their products by serving a business model through their artifacts. Digital transformation describes a sometimes broad process of change that may have multiple goals, while innovation focuses on the moment of invention and the implementation of that invention. Innovation may cause fundamental changes and vice versa, but both are not synonymous. Advancement of digitization and digital changes may be started as an innovation action. This may be catalyzed by new business opportunities, but ultimately must reach beyond the innovation function to reshape the entire organization (Globe, 2018). Businesses need a dynamic tool to support their digital innovation management efforts.

Artificial intelligence

Artificial intelligence is sometimes called machine intelligence, refers to the intelligence shown by machines in various situations, which is in contrast to the natural intelligence in humans; in other words, artificial intelligence refers to systems that can react similar to human intelligent behavior, including understanding complex situations, simulating human thinking processes and reasoning methods and successfully responding to them, learning and having the ability to acquire knowledge and reason to solve problems (Teece et al., 1997). The scientific study of algorithms and statistical models are used by computer systems that use patterns and inference to perform tasks rather than using clear instructions. Machine learning is the science of making computers learn about a specific subject without the need for an

explicit program. As a subset of artificial intelligence, machine learning algorithms create a mathematical model based on sample data or "training data" in order to predict or make decisions without overt planning (Du et al., 2019).

Research methodology

The sampling method was carried out in the form of theoretical saturation at the stage that no new material was obtained from the articles as a new index, and other indices were common in meaning and concept. In this study, Pardis Technology Park companies and its branches, including Azadi Factory and Hi-Wi centers were considered. Because these companies are active within the innovation ecosystem, they are familiar with the literature in this field, which facilitated the completion of the questionnaires. Questionnaires were sent through the Press Line program and within social network groups, and for some through phone and email. All these companies had the approval of knowledge-based company level 1 to 3 and the completers had educational qualifications of at least bachelor's degree to doctorate. After examining the opinions of the experts, it was determined that a consensus was reached by having an average above 4 for all indicators.

In adaptive neural fuzzy inference, the network separation method or lookup table (PG) was used in MATLAB 2023 software. In this method, the number of membership functions is 5 functions representing very low, low, medium, high and very high.

Research findings

A number of 290 articles were selected among the whole, which had the citation higher than 1. The texts of these 290 articles were studied, and finally 149 articles related to the selected topic and the literature and background of this research were used. In fact, the general goal and main question of this research was to model the innovation process centered on artificial intelligence, was carried out successfully with a very low model error during the test. As a result of reviewing these 149 articles and specialized texts, 189 indicators related to the issue of digital innovation were extracted. As the next goal, 42 main and effective indicators were obtained from this literature

Conclusion

In addition to the main goal and special goals of the research that were achieved through the presentation of the model, by examining the relationships obtained according to the surface diagrams, the sensitivity and impact of each component can be determined. "Variables" in the output, i.e. the degree of digitalization of the innovation process were analyzed. According to the findings and comparing them with the background and findings of previous researches, it can be stated that the sensitivity rate and impact of input 1, that is, the benefit of digital technologies based on artificial intelligence, is more than the other 4 inputs on the digital level of innovation process, in the sense that having these technologies is the main axis. It is less effective to benefit from the output; and if it is not present in the laboratory, from other components. The lowest sensitivity and impact on the output in the model belonging to the third and fourth components, i.e. network and smart learning, were identified next to the component of benefiting from technologies, and this could mean that in the conditions of benefiting from digital technologies, according to the findings of the research, it is suggested to design the intelligent model of innovation in different industries and for each industry separately for future research. In the literature, researchers encountered a wide range of these digital innovation models such as banking, schools and institutions of higher education, health, etc. The second suggestion is that future researches can design a separate model for each of the input components so that the input component of this research is placed in the

output position and the indicators determined in this research are used as their input. It is possible to design 5 other models according to the five components of this research, and connecting these models to develop a final and macro model can bring new achievements.