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Research Paper

# Modeling the Communication Technology Industry's Innovation Ecosystem using an Adaptive Neuro Fuzzy Inference System

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**Abstract**

**Information and communication technology (ICT) has provided a platform for the supply of innovative products and services. Therefore, the innovation ecosystem of communication technology (CT) has more searchable aspects separated from information technology (IT). This research aimed to provide insights into the state-of-the-art innovation ecosystem of the communication technology industry and suggests attitudes for future research. In this article, by review of more than 40 articles and chapters about the innovation ecosystem, the analysis has utilized data-driven tools, 173 questionnaires, and 20 specialized interviews with experts. The extracted factors of the research were analyzed using SPSS and AMOS software, and the research model was analyzed using the Adaptive Neuro-Fuzzy Inference System (ANFIS) in MATLAB software. The results show that the financial and economic factor has the most impact and the national and regional factor has the least importance in the innovation ecosystem model. The financial and economic factor is significantly different from other factors in terms of degree of importance.**

**Keywords** *Innovation Ecosystem, Innovation Management, Telecommunication Technology, ANFIS*

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## Introduction

The ICT sector is crucial as a driver of economic and social growth. Not only is it an important industry in its own right, it also provides the information and communication infrastructure without which modern economies could not function (Fransman, 2018). Innovation requires multifaceted interactions and knowledge flows (Haberstroh and Pinkwart, 2018). Innovation 'happens' as a result of the interdependency between players, processes, and their interactions (Fransman, 2018).The concept of an innovation ecosystem has gained increasing relevance since the mid-2000s as a framework that is better suited to emerging industries in which the determinants of the supply and the expectations of the demand are the relevant factors. Though the concept's origins are thought to be closely related to two other concepts: business ecosystem and innovation system, both of which were developed by Moore (1993) and Lundvall (1985), respectively (Arenal et al., 2021).Though there is no universal agreed definition, broadly speaking, an innovation ecosystem parallels the environmental concept, in which interrelated elements strive for equilibrium (Jackson, 2011). The interactions of the players are influenced by the architectural structure within which they exist (Fransman, 2018). The ICT Innovation Ecosystem describes the internal relationships and suggests appropriate models for these relationships for the whole industry. The ICT industry consists of two separate industries called information technology (IT) and communication technology (CT). There is currently no specific ecosystem for the CT industry, and all existing models address communication technology as part of a larger industry called ICT. This has prevented the actualization of many innovative aspects of CT. On the other hand, since there is no correct understanding of an exclusive innovation ecosystem for CT, the exact variables and factors of such an ecosystem are still unknown, and the indicators of an innovation ecosystem are always discussed generally for the whole ICT industry. As a result, the effect of some factors affecting the establishment of a specific innovation ecosystem model for the CT industry has never been measured.

## Background

Different definitions of the innovation ecosystem have been proposed, each of which has examined this concept from a specific point of view. Industrial management scholars are growing interested in the concept of innovation ecosystems (Adner & Kapoor, 2010; Autio & Thomas, 2014; Aarikka-Stenroos & Ritala, 2017; Valkokari et al. 2017; M¨oller & Halinen, 2018). An innovation ecosystem models the economic rather than the energy dynamics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation (Jackson 2011). These innovation ecosystems highlight the dynamic nature of innovation in order to create innovative results (Bacon, Williams, & Davies, 2020) and innovation performance (Carayannis & Campbell, 2009; Malerba, 2004). In contrast to the traditional industrial organization framework approach, an innovation ecosystem considers the business environment as a mutually interdependent system, not limited to any single industry or organization (Teece, 2007).Innovative ecosystems are described as "the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors" (Granstrand and Holgersson, 2020). The concept of innovation ecosystems has garnered much interest in recent years and in many ways offers a new and potentially fruitful perspective on innovation activities (Autio and Thomas, 2014). The appropriate methods for researching innovation ecosystems are thus still being defined (M. A. Phillips and Ritala, 2019). The definition of innovation ecosystems as "interconnected organizations, organized around a focal firm or a platform, and incorporating both production and use side participants, and focusing on the development of new value through innovation" (Autio and Thomas, 2014). However, the concept of innovation ecosystems is still in its infancy (Gomes et al., 2016; Valkokari, 2015). Researchers have even questioned the rigor and novelty of the concept, suggesting that more established terms could be used to a better effect (Oh et al., 2016). In summary, numerous definitions and approaches to the innovation ecosystem exist for academics, but it is always possible to explore the innovation ecosystem from new perspectives and dimensions. We will go over the literature on the ICT innovation ecosystem in the following section. According to the 2020 reports of the International Telecommunication Union (ITU), any country needs three types of ecosystems, i.e. national innovation ecosystem, entrepreneurship ecosystem, and technology ecosystem, to actualize innovation during their journey to reach digital transformation. These three interconnected ecosystems not only support an innovative environment from brainstorming to marketing but also serve as a complement to the IIE of any country. Fransman (2010 and 2018) states that the first step to analyzing the IIE is to identify innovative vertical relationships between the ecosystem actors, whose organizational innovation will influence the products and processes. Based on the same approach, the four key actors of an innovation ecosystem are; equipment providers; network operators; content and app providers, and end users. Except for the vertical relationships between the actors that determine the overall shape of the ecosystem, horizontal relationships in each layer of the ecosystem are of special importance. Many products, services, and even raw knowledge (not converted into a product or service) are exchanged through horizontal relationships between actors. The above-mentioned four key actors of the IIE coexist to establish beneficial interactions and relationships. The major problem with the following multilayer model is that it does not define the internal relationships of an ecosystem in a linear manner. Considering the dynamic nature of innovation, the relationships of an ecosystem and even the ecosystem itself never stop and are always fundamentally changing (Fransman, 2018).

## Method

The most important aspect of the research (final output of the system), the elements and indicators that relate to them are shown in Table 1 (Primary and intermediate input of the system) in the path of ANFIS design and general model information. Expert opinion and literature review were used to extract and categorize the factors and indicators in this table. As a result, the relevant mathematical model in this research includes a main ANFIS in the field of Communication Technology's Innovation Ecosystem, as well as six Sub-ANFIS that represent the aggregation of the effects of each indicator on the important components. In addition, Figure 1 depicts the research conceptual model in one view.

Table 1

*The Main Component, Factors and Indicators of the research model*

| Main Component | Factors | Index | Indicators |
|---|---|---|---|
| Communication Technology Innovation Ecosystem (CTIE) | Institutional | I1 | Effects of institutions contributing to the innovation ecosystem |
| | | I2 | Effective composition of institutions |
| | | I3 | Facilitating role of policymaking institutions |
| | | I4 | Sovereign influence of the Ministry of Communications and Information Technology |
| | | I5 | Sovereign influence of the Ministry of Industry, Mines and Trade |
| | | I6 | Sovereign influence of Communications Regulatory Authority (CRA) |
| | | I7 | Sovereign influence of TCI |
| | | I8 | Sovereign influence of Iran Telecommunication Company and its subsidiaries |
| | | I9 | Role and performance of content providers (CP) |
| | | I10 | Role and performance of fixed communication providers (FCP) |
| | | I11 | Role and performance of providers of fixed wireless access (FWA) |
| | | I12 | Role and performance of mobile network operators (MNO) |
| | | I13 | Role and performance of manufacturers of |

| Main Component | Factors | Index | Indicators |
|---|---|---|---|
| | | | developers of digital service platforms (DSP) |
| | | I14 | Size, quality, type, activities, and relationships of institutions operating in the CT Industry |
| | Financial and Economic | FE1 | Financial performance of active startups in the communication technology industry |
| | | FE2 | Financial performance of incubators and accelerators |
| | | FE3 | Investment volume of angle investors |
| | | FE4 | Investment volume of venture capitals |
| | | FE5 | Capital market dynamics |
| | | FE6 | Effects of economic environment on the innovation ecosystem |
| | | FE7 | Ways of easy financing |
| | | FE8 | Quantity and quality of incentives |
| | | FE9 | Economic added-value of innovation |
| | | FE10 | R&D Intensity among the innovation ecosystem |
| | | FE11 | Quality and quantity of participation of angel investors and venture capitals in the communication technology industry |
| | | FE12 | Quality and quantity of financial and economic exemptions for knowledge-based activities in the communication technology industry |
| | | FE13 | Profit margin in the communication technology industry |
| | | FE14 | The purchasing power of customers for services and products of the communication technology industry |
| | | FE15 | Global economic indicators of industry innovation |
| | | FE16 | Effects of different types of economic constraints on the communication technology industry |
| | | FE17 | Rate and duration of return on investment in the communication technology industry |
| | | FE18 | Position of the communication technology industry in Iran's economic indicators |
| | | FE19 | Economic effects of sanctions on the communications technology industry |
| | | FE20 | Effects of the COVID-19 pandemic on the economic factors of the industry and its ecosystem |
| | Innovation Management | IM1 | Innovation management status in institutions constituting the innovation ecosystem |

| Main Component | Factors | Index | Indicators |
|---|---|---|---|
| | | IM2 | Percentage of commercialized innovations in the innovation ecosystem |
| | | IM3 | Quantity of innovative scientific output of universities and research centers |
| | | IM4 | Influence of innovation culture on institutions constituting the innovation ecosystem |
| | | IM5 | Influence of entrepreneurial culture on institutions constituting the innovation ecosystem |
| | | IM6 | Position of the innovation ecosystem in the national innovation system |
| | | IM7 | Innovation spillover in the industry |
| | | IM8 | Regularity and transparency of innovative strategies |
| | | IM9 | Quality of relationship between science ecosystem and innovation ecosystem |
| | | IM10 | Quality of relationship between technology ecosystem and innovation ecosystem |
| | | IM11 | Quantity of innovative activities in universities and research centers |
| | | IM12 | Quantity of R&D activities in institutions of the innovation ecosystem of CT |
| | | IM13 | Number of patents |
| | | IM14 | Quantity of commercialized innovative products and services in the communication technology industry |
| | **Business** | B1 | Quantity of entrepreneurship and Create new job opportunities in the innovation ecosystem |
| | | B2 | Ease of commercialization in the innovation ecosystem |
| | | B3 | Business environment dynamics |
| | | B4 | Degree of ease of running businesses in the communication technology industry |
| | | B5 | Number and types of barriers to entry into the communication technology industry |
| | | B6 | Number and types of incentives and drivers for entering the communication technology industry |
| | | B7 | Market elasticity and demand for the communication technology services and products |
| | | B8 | Capacity and feasibility of producing the complements of products and services of communication technology |
| | | B9 | Number and types of legal restrictions on |

| Main Component | Factors | Index | Indicators |
|---|---|---|---|
| | | | business |
| | | B10 | Degree of dependence of the communication technology industry on imports |
| | | B11 | Ease of access to technologies, goods, and services related to the communication technology industry |
| | | B12 | Quantity and quality of national and international exhibitions related to communication technology |
| | | B13 | Development and availability of communication technology infrastructure as a prerequisite for businesses |
| | National and Regional | NR1 | Effects of political environments and relations on innovation ecosystem of communication technology |
| | | NR2 | National status of communication technology development as a complementary technology |
| | | NR3 | Regional and international status of CT development |
| | | NR4 | Regional and international status of communication technology development as a complementary technology |
| | Science and Technology | ST1 | National status of the communication technology industry compared to regional and international standards |
| | | ST2 | Quality of relationship between communication technology industries and the relevant universities and academic centers |
| | | ST3 | Role and performance of science and technology parks |

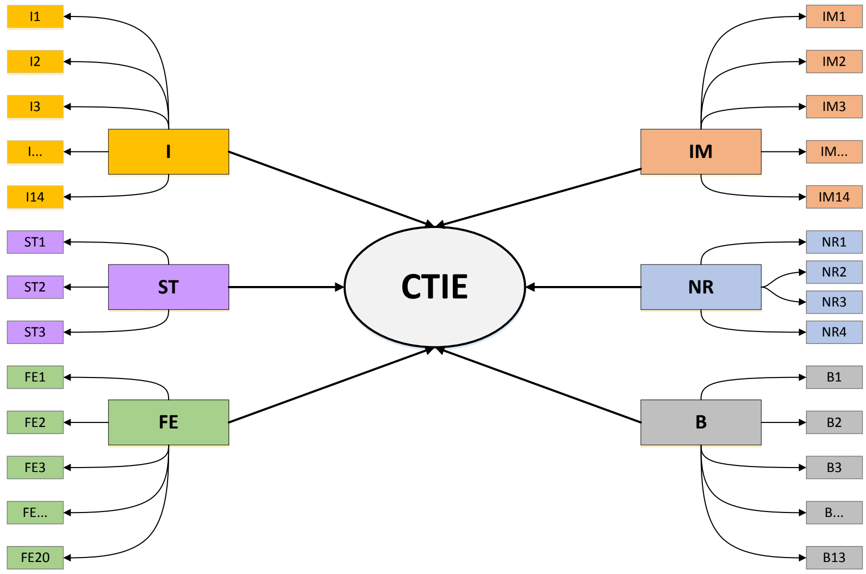


Figure 1

*The Conceptual Model*

Table 2 depicts how the data and values obtained for designing the aforementioned ANFIS inferential rules are gathered (meaning Ei Certified I th).

Table 2

*Model's Data Gathering*

| | Random values generated for experts | | | | | | Expert Opinion |
|---|---|---|---|---|---|---|---|
| **Ei** | **Institutional** | **Financial and Economic** | **Innovation Management** | **Business** | **National and Regional** | **Science and Technology** | CTIE |
| **E1** | 7 | 5 | 10 | 3 | 2 | 4 | **5** |
| **E2** | 9 | 4 | 9 | 7 | 7 | 7 | **7** |
| **E3** | 3 | 10 | 4 | 5 | 6 | 8 | **6** |
| **…** | … | … | … | … | … | … | **…** |
| **E80** | 9 | 3 | 6 | 8 | 3 | 1 | **5** |
| **E81** | 1 | 4 | 7 | 3 | 5 | 2 | **4** |
| **E82** | 7 | 3 | 4 | 6 | 2 | 9 | **5** |

Error Tolerance is also proportional to the magnitude of the error and is used to establish a criterion for terminating training. The designed ANFIS with 40 training courses (EPOCH) achieved an acceptable error rate. The amount of this error in the main ANFIS and Sub-ANFIS after 40 training courses is shown in Table 3. The designed model has 57 inferential rules and 6 inputs (6 factors) and the output of CTIE. Figure 2 depicts the 57 rules.

Table 3

*Error Rates in Designed ANFIS*

| ANFIS | Error |
|---|---|
| I | $1.6766 \times 10^{-6}$ |
| FE | $1.2795 \times 10^{-6}$ |
| IM | $1.7725 \times 10^{-6}$ |
| B | $1.2364 \times 10^{-6}$ |
| NR | $2.3849 \times 10^{-6}$ |
| ST | 0.0077716 |
| **CTIE** | $\mathbf{6.1379 \times 10^{-6}}$ |

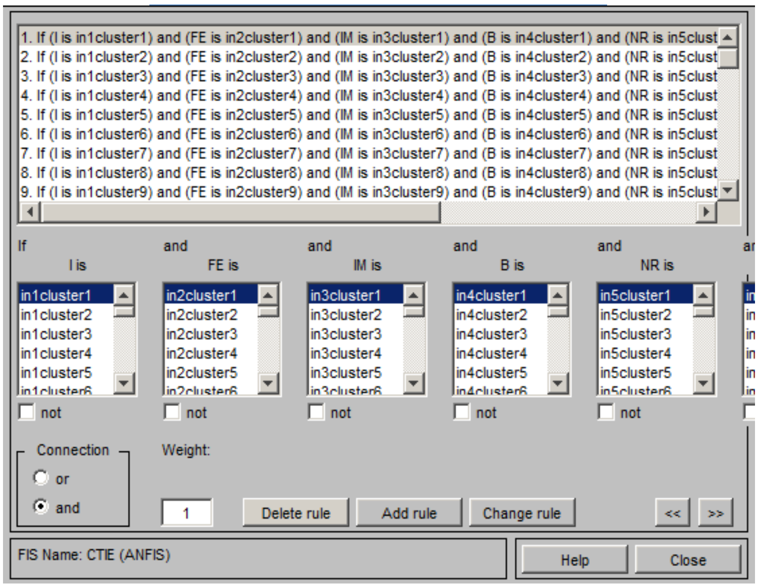


Figure 2

*Rules of Fuzzy Inference*

To evaluate the factors influencing CTIE, we first create a main ANFIS. Its structure is made up of 57 rules and 5 layers, with the first layer dedicated to 6 inputs (Sub-ANFIS), which are the following factors: Institutional (I), Financial and Economic (FE), Innovation Management (IM), Business (B), National and Regional (NR), and Science and Technology (ST). The model's output is also included in the fifth layer. The main ANFIS inputs (6 factors) are each a Sub-ANFIS, which are adaptive fuzzy neural systems (Sub-ANFIS) designed for each component. The primary ANFIS system inputs are depicted. The figures 3 and 4 depict the designed ANFIS for two out of the six main system inputs (based on the indicators and indexes in Table 1).

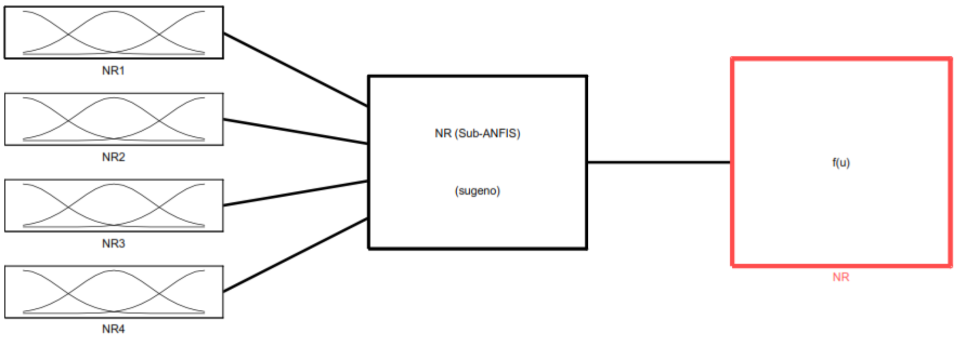


Figure 3

*ANFIS 5 - National and Regional (NR)*

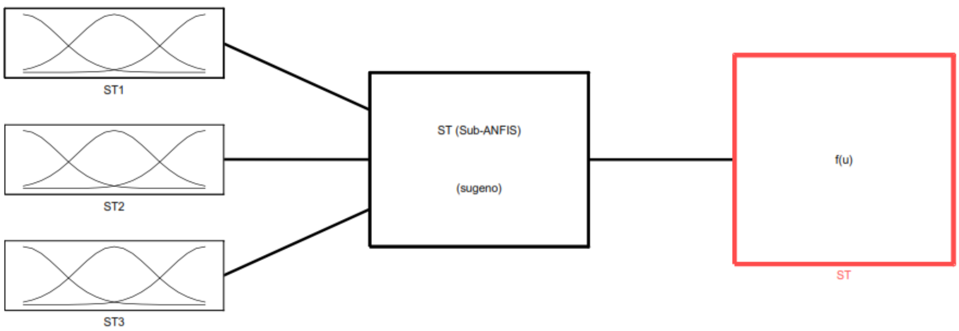


Figure 4

*ANFIS 6 - Science and Technology (ST)*

## Findings

The combination of different modes of factors will result in different outputs of the designed system, according to the database of rules extracted for this research. Figures 5 to 8 depict the curves of the factors influencing the CTIE issue. Each of these factors has been compared to each other, either independently or in pairs, and their impact on the research's main component has been demonstrated. In Figures 5 and 6, increasing the number of "Business" and "Financial and Economic" variables in the range of zero to five has a less influence on boosting CTIE than values more than five. In other words, for numbers bigger than four, they nearly double the output variable (except that the increasing trend of the business factor ends with an increasing rate compared to the initial interval and with a decreasing rate for the financial and economic factor). That is, the six components' influence makes sense over time. They may, however, have less of an impact on system output at beginning values.

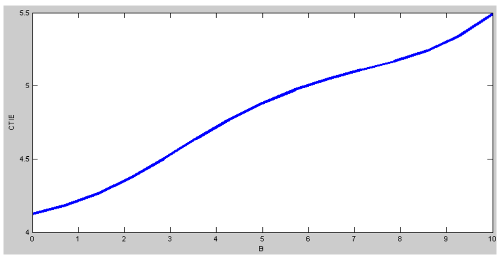


Figure 5

*Impact of Changes in "Business" Factor on ICTE*

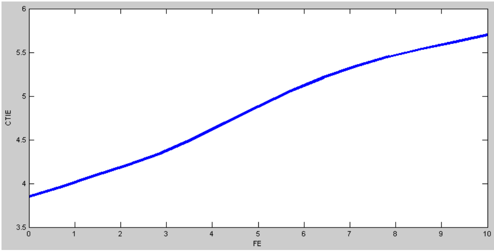


Figure 6
*Impact of Changes in "Financial and Economic" Factor on ICTE*

Figures 7 and 8 are three-dimensional diagrams developed by ANFIS that depict the decision level (designed). The construction of these curves is such that it illustrates the effect of binary values of input components on the research subject's output variable. These curves are shown for pairs ST and IM as well as B and FE.

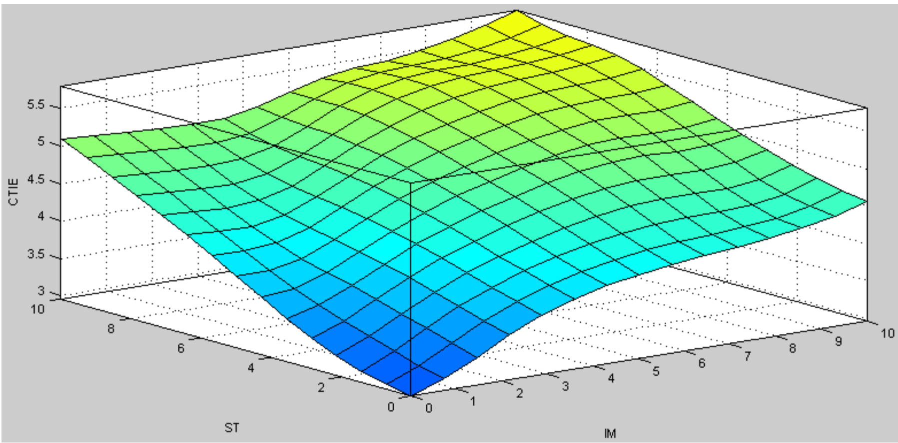


Figure 7
*Comparison Curve for Effect of ST and IM Factors on CTIE*

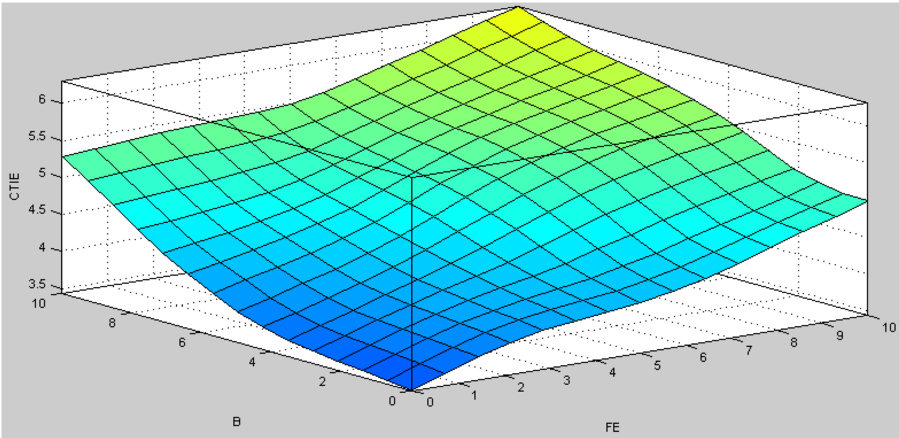


Figure 8

*Comparison Curve for Effect of B and FE Factors on CTIE*

A questionnaire was created to assess the elements influencing the improvement of open banking innovation using a digital transformation approach, and professionals in this field (a total of 20 persons) were asked to provide their thoughts on the six CTIE level factors. The survey was recognized by highlighting the relevant continuum with values ranging from 0 to 10. Tables 4 shows the input and output values for institutional (I), financial and economic (FE), innovation management (IM), business (b), national and regional (NR), and science and technology (ST).

Table 4

*All Factors Sub-ANFIS Input and Output Values*

| **Institutional** | | **Financial and Economic** | | **Innovation Management** | | **Business** | | **National and Regional** | | **Science and Technology** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **I** | **4.17** | **FE** | **3.82** | **IM** | **5.37** | **B** | **4.86** | **NR** | **4.12** | **ST** | **5.63** |
| I1 | 3.77 | FE1 | 3.80 | IM1 | 6.15 | B1 | 6.05 | NR1 | 5.76 | ST1 | 4.88 |
| I2 | 5.83 | FE2 | 4.00 | IM2 | 4.80 | B2 | 5.82 | NR2 | 4.97 | ST2 | 3.80 |
| I3 | 4.96 | FE3 | 4.15 | IM3 | 6.26 | B3 | 6.25 | NR3 | 3.72 | ST3 | 5.25 |

| Institutional | | Financial and Economic | | Innovation Management | | Business | | National and Regional | | Science and Technology |
|---|---|---|---|---|---|---|---|---|---|---|
| I4 | 4.52 | FE4 | 3.10 | IM4 | 4.78 | B4 | 4.87 | NR4 | 4.28 | |
| I5 | 4.85 | FE5 | 3.51 | IM5 | 5.36 | B5 | 6.35 | | | |
| I6 | 4.47 | FE6 | 4.55 | IM6 | 5.54 | B6 | 5.83 | | | |
| I7 | 4.60 | FE7 | 3.47 | IM7 | 4.27 | B7 | 6.44 | | | |
| I8 | 3.89 | FE8 | 4.05 | IM8 | 4.62 | B8 | 4.72 | | | |
| I9 | 3.03 | FE9 | 3.49 | IM9 | 6.08 | B9 | 6.24 | | | |
| I10 | 5.72 | FE10 | 2.90 | IM10 | 5.74 | B10 | 3.85 | | | |
| I11 | 5.60 | FE11 | 3.63 | IM11 | 5.53 | B11 | 6.45 | | | |
| I12 | 3.68 | FE12 | 4.87 | IM12 | 6.51 | B12 | 3.34 | | | |
| I13 | 5.75 | FE13 | 3.33 | IM13 | 4.65 | B13 | 5.15 | | | |
| I14 | 3.74 | FE14 | 4.72 | IM14 | 3.50 | | | | | |
| | | FE15 | 3.20 | | | | | | | |
| | | FE16 | 3.65 | | | | | | | |
| | | FE17 | 4.05 | | | | | | | |
| | | FE18 | 4.47 | | | | | | | |
| | | FE19 | 2.62 | | | | | | | |
| | | FE20 | 4.23 | | | | | | | |

Following the deployment of Sub-ANFIS, their output is used as the primary ANFIS input to assess the factors influencing CTIE. The values of these inputs and outputs are shown in Table 5 and Figure 9 of the main ANFIS rule database.

Table 5.

*ANFIS Input and Output Values of CTIE*

| I | FE | IM | B | NR | ST | CTIE |
|---|---|---|---|---|---|---|
| **4.17** | 3.82 | 5.37 | 4.86 | 4.12 | 5.63 | **4.50** |

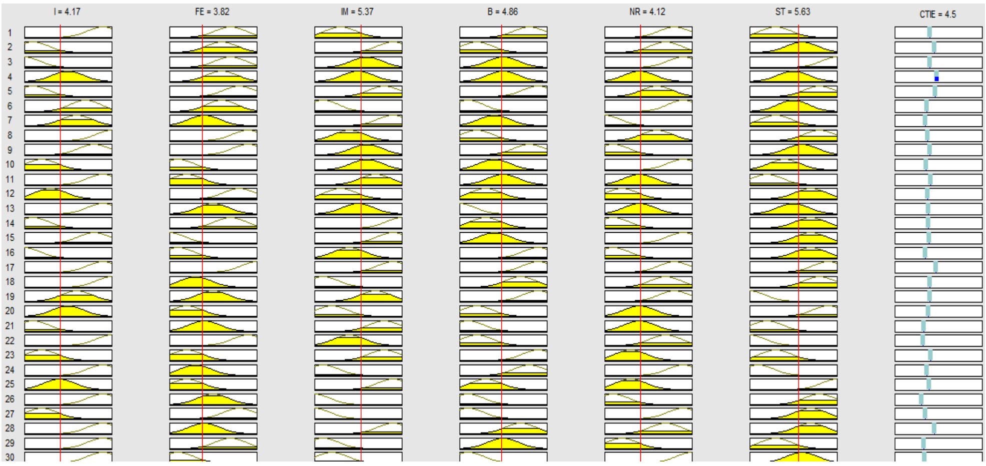


Figure 9

*CTIE Rules Database*

As can be seen, the level of innovation ecosystem of communication technology industry is estimated at 4.50, which is in the average range. The mathematical model's validity was evaluated prior to building and executing the system designed in the case study. Model testing and validity improve the model's dependability and applicability. To validate the mathematical model, two procedures were used: "testing and examining the data set" and "limit condition test." Validation was carried out using test data to assess the ability of the generated fuzzy inference system to generalize, and we used the most recent data set (review data) to control the problem of overfitting. The planned ANFIS error trend was evaluated for this purpose in the current work, and Figures 10 and 11 clearly indicate the consistency between the training data and the test and review data. The * sign (star) in the diagram above represents the ANFIS output, and the circle symbol represents the test data, with the mean error determined as 6/1379 x $10^{-7}$. In Figure 12, the asterisk represents the system output and the plus sign represents the survey data, which is nearly similar, suggesting that the developed ANFIS lacks Over Fitting.


Figure 10

*Comparison Diagram of ANFIS Output and Test Data*

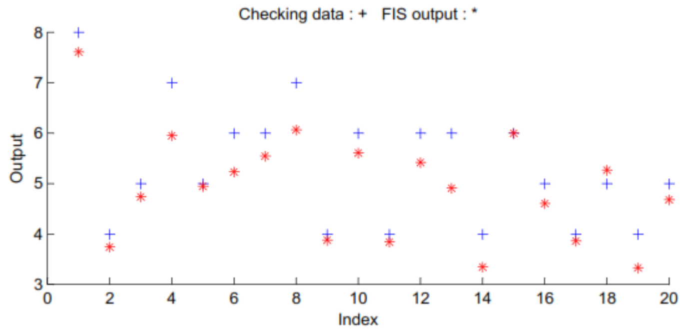


Figure 11

*Comparison Diagram of ANFIS Output and Survey Data*

The value of the main ANFIS input variables is changed in different limit states (very high and very low) in this test, and the output of the model is investigated in response to these changes. In other words, the goal of this test is to validate the appropriate behavior (reliability) of the obtained mathematical model in the face of changes in input data values.

Table 6

*The Effect of Simultaneous Changes in Inputs and Output*

| **ANFIS Outputs** | **ANFIS Inputs** | | | | | |
|---|---|---|---|---|---|---|
| **CTIE** | **I** | **FE** | **IM** | **B** | **NR** | **ST** |
| **0.03** | 0 | 0 | 0 | 0 | 0 | 0 |
| **4.88** | 5 | 5 | 5 | 5 | 5 | 5 |
| **9.96** | 10 | 10 | 10 | 10 | 10 | 10 |

As shown in Table 6, the model responds logically to changes in input variables ranging from very low (zero) to very high (10). This test was performed on all eight Sub-ANFIS, and they all demonstrated logical behavior toward the input limit values, indicating the validity of the designed model. To evaluate the amount of output changes vs input changes, choose two inputs with the greatest effect on output and the least effect on output, and examine the effect of their changes on output. We choose the FE input as the most effective factor on the output and increase its value by one unit for this reason. Table 7 and Figure 12 indicate the outcome of this adjustment.

Table 7

*Rate of Output Change in Exchange for FE Change*

| I | **FE** | IM | B | NR | ST | **CTIE** |
|---|---|---|---|---|---|---|
| 4.17 | **4.82** | 5.37 | 4.86 | 4.12 | 5.63 | **4.76** |

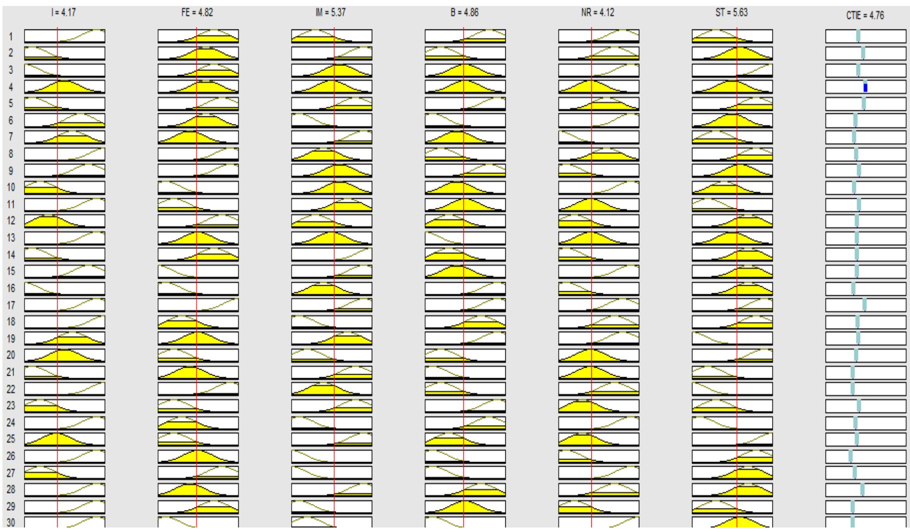


Figure 12

*Rate of Output Change in Exchange for FE Change*

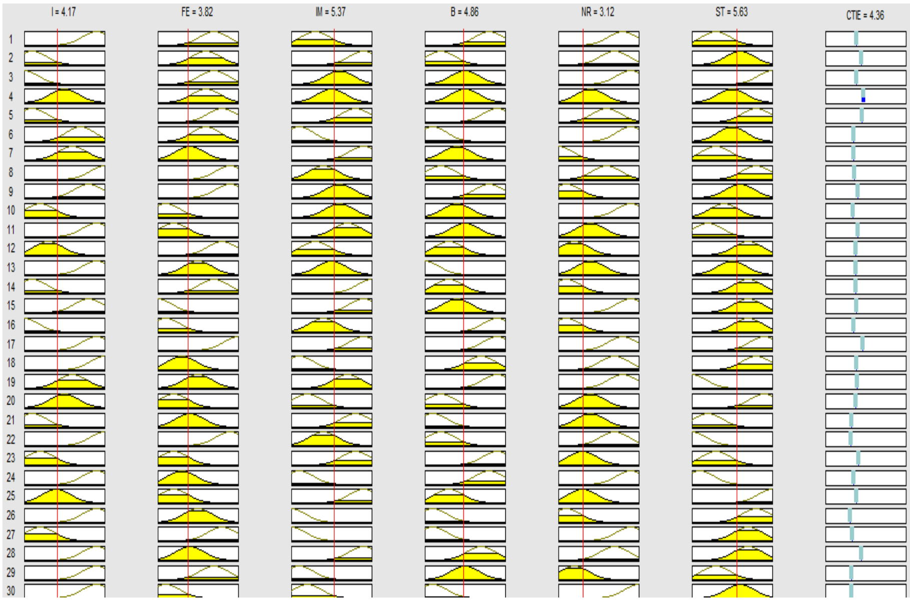


Figure 13

*Rate of Output Change in Exchange for NR Change*

Furthermore, by holding all other variables constant, we investigate the NR input as a unit of reduction and the output changes. Table 8 and Figure 13 indicate the effects of this adjustment.

Table 8

*Rate of Output Change in Exchange for NR Change*

| I | FE | IM | B | **NR** | ST | **CTIE** |
|---|---|---|---|---|---|---|
| 4.17 | 3.82 | 5.37 | 4.86 | **3.12** | 5.63 | **4.36** |

As can be observed, a change in the NR component causes a 0.14 change in the output. In comparison, the same amount of change in the FE component only results in a change of 0.26. That is, the influence of FE on output exceeds the effect of NR on output.

## Conclusion and Suggestion

As shown by the results, the Financial and Economic factor with the first rank and weight criterion of 0.26 is the most important variable among the factors influencing the communication technology industry's innovation ecosystem model and can be the primary decision criterion in the field under study. And, with a weight criterion of 0.10, the National and Regional factor is ranked last and is considered to have the least influence in the relevant decision. Innovation Management factor with a weight of 0.16, Business factor with a weight of 0.15, Institutional factor with a weight of 0.13, and Science and Technology factor with a weight of 0.11 are in the next categories of factors affecting communication technology industry’s innovation ecosystem in Iran. Thus, the importance of Financial and Economic factor has a significant distance from other factors. Innovation Management and Business factors are significantly less important than Financial and Economic factor, although these two factors are almost equally important in the model. Institutional and Science and Technology factors are less important than the previous factors, and in the end, National and Regional factor is the least important factor in the innovation ecosystem model of the communication technology industry, although its importance is not far from the importance of Science and Technology factor. As a result, Iranian actors of communication technology innovation ecosystem in the development of this ecosystem, must first pay attention to financial and economic challenges such as communication technology market’s dynamics, R&D intensity, financing ways and investment return rate in this industry. Activity in an innovation ecosystem without taking economic risks will lead to failure for the actors. The performance of incubators, accelerators, angel investors, and venture capitals also has a substantial impact on the ecosystem's overall functioning. If the actors wish to offer innovative products and services, they must consider the industry's dependency on imported as well as its profit margins. Because disregarding these cases will result in a stop to innovative activity.

Covid-19 has already had a substantial impact on the innovations of industry operations, but some of the modifications have been economically beneficial due to greater usage of communication technology infrastructure. On the other side, for the innovation ecosystem model to work successfully, concerns linked to innovation management must be completely current in the ecosystem's body. The quantity of patents registered in the sector, as well as the amount of commercialized innovations of ecosystem actors, are crucial in this regard. Finally, paying attention to business-related issues, such as barriers to entrance and the degree of ease of doing business in the industry, is critical. However, the role of institutions, particularly regulators and legislators, in improving the performance of the ICT industry's innovation ecosystem model should not be underestimated.

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