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# Poultry Industry Regional Innovation System Model

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Abstract

The poultry industry is one of the most important economic resources, having one of the most voluminous parts of human resources. Its scope and the growing consumption of related products have raised the need for innovation in it. This study aimed to provide a poultry industry regional innovation system model, with a pilot study on three provinces of Guilan, Mazandaran, and Golestan in Iran.This was a pluralistic, applied, descriptive survey with quantitative -qualitative data. The statistical population included Iranian experts in the poultry industry. In addition to using library resources, questionnaires and interviews were also used to collect data. The snowball sampling was used to select experts. Five experts were selected for interviews and 32 received questionnaires. Data were analyzed using SPSS and Modeler software, as well as the multi-layer perceptron artificial neural network. This study employed the functional-structural analysis approach to provide apoultry industry regional innovation system model. Overall, 15 actors, 29 institutions and six functions were identified. Data analysis confirmed the model.The findings showed that the most important indices of structural elements were Islamic Republic of Iran Customs Administration (IRICA) among regional innovation system actors, and implementing policies to attract domestic technology and international capital among regional innovation system institutions. In addition, the results showed that all the functions of the innovation system were of great importance, among which only the innovation and entrepreneurship indices had a relatively lower performance, which requires policymakers to take measures to improve them.

***Keywords:***
***Poultry industry; regional innovation system; structural-functional approach***

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## INTRODUCTION

According to statistics, the world poultry meat production in 2017 was 120.5 million tons, which has increased by 1.1 percent compared to 2016. Meat consumption has risen across the world from about 20 units in 1961 to 41 units in 2015 (FAO, 2019). FAO expects that global meat production increases by 16 percent in 2025 compared to the base period of 2013-2015. This is because of the development in most developing countries leading to inclusion of more protein in the diets. In response to the increasing global demand, poultry meat has the most important role in meat production in the world, since its production and final price are cheaper. This has made poultry meat the first choice of producers and consumers, especially in developing countries.

In Iran, per capita consumption of meat has inclined towards poultry meat. According to Ministry of Agriculture's statistics, the per capita consumption of poultry meat was 27 kg and the per capita consumption of red meat was 12 kg in 2016.Their statistics also showed that red meat production in 1978 was 397,000 tons, which increased to 860,000 tons in 2018. The poultry meat production has also increased from 160,000 tons to 2,400,000 tons, that is approximately 15-fold increase (Agriculture Jihad Organization, 2018).This indicates inclination of the community towards poultry meat. Therefore, in keeping with the change in taste of the community, the responsible authorities in the poultry industry need to adopt new procedures and innovations to meet the increasing demand.

Developed countries experience indicate that innovation is necessary for improving productivity and economy. Innovation is one of the most important factors for countries to achieve competitive advantage and create strategic superiority in the world. Particularly in the food supply sector, which is country-specific, self-sufficiency should be considered by all practitioners and producers. Therefore, all the components involved in the process of improving innovation in the industry, which raise the notion of an innovation system, must be identified.The innovation system approach is a common, comprehensive and systematic paradigm for analyzing the complexities of the innovation process (Kebebe et al., 2015; Klerkx et al., 2012; Ortiz et al., 2013; Turner et al., 2016).

An innovation system is generally a network of organizations, producing companies and individuals that focus on provision of new products and processes by working with institutions and various policies that affect communication, sharing, access, exchange, and using knowledge (Hall et al., 2006). An innovation system can be border-sensitive because it can be viewed, internationally, nationally and regionally (Klerkx & Nettle, 2013; Lamprinopoulou et al., 2014; Turner et al., 2016). Therefore, it is important to assess the performance of innovation systems regionally, and show factors in each region that can improve the performance of innovation systems and industry of that region (Minh, 2019).

This study tried to understand how a poultry industry regional innovation system can enhance the industry as one of the largest producing industries that produce a strategic product. Achieving this goal requires the localization of a specific industry model identifying elements fully relevant to industry innovation. Using functional-structural analysis approach, this study tried to answer two questions: 1) What are the most important structural elements of poultry industry regional innovation? 2) What are the importance and performance of functional elements in the poultry industry regional innovation system?

The regional innovation system does not have a definition that is generally accepted, but according to Doloreux (2002) it can be defined as a set of general and specific interests, formal institutions, and other interactive organizations that conform to organizational or institutional arrangements and relationships. Creating, using, and disseminating

knowledge are useful, defined (Guerreiro & Pinto, 2012). In his definition of Cooke et al (1997), he defines a regional innovation system as a system in which firms and other organizations are systematically engaged in interactive learning in an institutional domain in which they are embedded (Muscio et al., 2015). This definition emphasizes the following topics (Jin et al., 2015):

Complement traditional approaches to regional development such as industrial poles, industrial clusters and industrial zones.

It is based on a fundamental principle that regional proximity and proximity of companies in one region can lead to increased synergy and development in the region.

The concept of interactive learning, the concept of community, the concept of inclusion

Until recently, the development and expansion of agricultural innovation were considered a linear process involving public sector research and research organizations, which implicitly assumed that innovation was the product of research (Mofakkarul Islam et al., 2013). Agricultural innovations, however, have basically a system that involves different actors as well as their interactions and collaborations in an institutional setting (Knickel et al., 2009). Thus, it can be stated that agricultural innovation is the result of interactions between actors such as supply chains, economic systems, policy environments and social systems (Klerkx et al., 2012). Actors in the innovation system are various, divided into the political system (including policymakers in innovation), the knowledge utilization system (consisting of a wide range of companies), the knowledge production system (including technology centers and research institutes, universities and official training centers), and the financial system (all innovation supporting organizations).

In addition to actors, institutions are also very important in an innovation system. North (1990) defines institutions as the society game rules or formal or human constraints that shape human interaction. They are composed of formal rules (statute law, common law, regulations) and informal restrictions (social norms, habits, routines, practices) and the characteristics of getting them done (Oyelaran-Oyeyinka, 2017).

Research has shown that the interactions between these innovation systems components take place in a specific institutional setting, and the specific institutional context properties in each region have a profound impact on the economy, companies and entrepreneurial activities of individuals (Acs et al. 2016; Autio et al. 2014; Leyden 2016). Therefore, there are significant structural differences between innovation systems at the regional level and in different contexts (Oughton et al., 2002). Based on these differences, the typology of regional innovation systems in each region is important, which classifies the regions according to innovation practices, types of learning, and communication of innovation system elements (Isaksen & Trippl, 2017).

Other indices in regional innovation systems are functions. Innovation system functions are the types of events that are necessary to create innovation in a system (Bergek et al., 2008; Suurs et al., 2010). In fact, functions of the innovation system are the goals of interactions between actors and entities in the innovation system that the system aims to achieve (Hellsmark et al., 2016).

There are also different approaches to discussing innovation systems. Most studies on innovation systems, have primarily relied on one structural or functional approach (Klerkx et al., 2012; Turner et al., 2013; Turner et al., 2016), which has focused on innovation system components as structures, or innovation system results as functions (Amankwah et al., 2012; Hermans et al., 2015; Hounkonnou et al., 2012; Ortiz et al., 2013; Totin et al., 2012; Schut et al., 2015). However, several studies have suggested the functional-structural analysis framework to identify importance/function of innovation system elements (Kebebe et al., 2015; Lamprinopoulou et al., 2014). The basic idea is

based on the principle that weak structural factors associated with each function are identified according to the relationship and interaction of functions and structural factors; and strengthened using policy tools and policy recommendations, resolving the problems hindering system development (Wieczorek & Hekkert, 2012). Further, each structural and functional approaches are described separately:

*Functional approach:*The functions of innovation system are important events that are essential for innovation in a system (Bergek et al., 2008; Suurs et al., 2010). In other words, the functions of innovation system are the result of the interactions between actors and institutions in innovation system that the system intends to achieve (Hellsmark et al., 2016). Various researchers in their research have tried to identify the functions of innovation systems. Table 1 shows the functions identified by various researchers:

Table 1
*Functional Factors Identified by Researchers*

| Functions | Source |
|---|---|
| R&D activities; supply of scientific and technical services; diffusion of information, knowledge, and technology; policy making; design and implementation of institutions concerning patents, laws, standards, etc.; diffusion of scientific culture; professional coordination | Galli & Teubal (1997) |
| Entrepreneurial activities; knowledge development (learning); knowledge diffusion through networks; guidance of the search; market formation; resources mobilization; support from advocacy coalitions | Negro et al. (2007) |
| Linkage the complementary knowledge partners; formation of technology markets, external financing of innovation | Wang et al. (2011) |
| Resource mobilization; market formation; influence on the direction of search; entrepreneurial experimentation; formation of social capital, legitimation; knowledge development and diffusion | Bergek et al. (2008); Hellsmark et al. (2016); Perez Vico (2013) |
| Entrepreneurial activities; knowledge development; network formation and knowledge diffusion; guidance of search; market formation; resource mobilization; support from advocacy coalitions | Hermans et al. (2019); Suurs et al., (2010); Turner et al. (2016) |
| Entrepreneurial activities; knowledge development; knowledge exchange; guidance of the search; market formation; resource mobilization; creation of legitimacy | Wieczorek et al., (2013); Wieczorek et al., (2015) |

*Structural approach:* The performance of the functions in innovation systems relate to the presence and quality of structural elements. All aspects of the economic and institutional structure that affect learning, researching and exploration are defined as the structural elements in innovation systems (Wieczorek & Hekkert, 2012). Various researchers in their research have tried to identify the structural elements of innovation systems. Table 2 shows the structural elements identified by various researchers:

Table 2
*Structural Factors Identified by Researchers*

| Indices | Subject | Source |
|---|---|---|
| Universities; public sector (public r&d organizations); business sector; new infrastructural components (including innovation infrastructure and policy development block sectors) | Actors of innovation systems | Galli & Teubal (1997) |
| Type 1 (formal laws that apply to everyone and cannot be waived); Type 2 (rules established between groups of individual agents, etc.) | Institutions of innovation systems | Coriat & Weinstein (2002) |
| Firms; firms in interaction with other firms and knowledge infrastructure; inter-sectoral knowledge flows in an input-output perspective; national education, labor markets, financial markets, welfare regimes and intellectual property regimes | Analytical framework of innovation systems | Lundvall (2005) |
| enterprises, financial institutions, research institutes, educational institutes, government organizations, agencies, etc. | Actors of innovation systems | Guo (2010) |
| Actors (civil society; companies; knowledge institutes; government; ngos; legal organizations, financial organizations); institutions (hard: rules, laws, regulations, instructions; soft: customs, common habits, routines, established practices, traditions, ways of conduct, norms, expectations); interactions (at level of networks; at level of individual contacts); infrastructure (physical; knowledge; financial) | Structural dimensions of innovation systems | Wieczorek & Hekkert (2012) |
| Formal institutions (laws etc.); informal institutions (common law, customs, traditions, work norms, norms of cooperation, conventions, practices, etc.) | Institutions of innovation process | Edquist (1997) |
| Economic environment; academic environment; public environment | Actors of innovation systems | Gust-Bardon (2015) |
| Individuals; organizations; research and educational institutes; government agencies; financial and commercial organizations | components ofinnovation systems | Etzkowitz & Ranga (2015) |
| Government; research institutions; universities; private firms; intellectual property rights laws; funding allocation | components ofinnovation systems | Zhao et al., (2015) |
| Economic; scientific and technological; social; political and legal; ecological and geographical | components ofinnovation systems | Mikhaylova (2015) |

The important point is that all researchers have relied on actors and institutions to introduce structural elements. Actors are in fact innovation implementers, whose interactions are of great importance. Innovation interactions are defined as various partnerships between companies, universities, government agencies, laboratories,and financial institutions to achieve R & D and innovation goals (Block & Keller, 2009). Institutions are

also important in the innovation system and are defined as a set of habits, routines, executive practices, rules and policies that regulate relationships and interactions between individuals and groups (Vargo et al., 2015). Institutions exist both formally and informally (Shu et al., 2016). Edquist (1997) expresses three functions for institutions that are providing information and reducing uncertainty, managing conflicts and cooperation, providing incentives (Berthinier-Poncet, 2013). Public and private sector institutions have a significant impact on companies' motivation to employ norms, values, attitudes and routine practices (Gao & Van Lente, 2008). Therefore, the structural elements include a set of actors that together form institutions that create innovation.According to theoretical foundations, the model used in this study is presented based on structural-functional analysis (Figure 1).

*Research questions*

(1) What are the most important structural elements of poultry industry regional innovation?

(2) What are the importance and performance of functional elements in the poultry industry regional innovation system?

## METHODOLOGY

This was a pluralistic, applied, descriptive survey with quantitative-qualitative data, because it described and explains what is present, considering circumstances or relationships, common beliefs and current processes. This was a pluralistic study, because it used combined and pluralistic methods to examine various aspects of the subject. This study aimed to provide a poultry industry regional innovation system model, with a pilot study on three provinces of Guilan, Mazandaran, and Golestan in Iran. The statistical population of this study included industrial managers and entrepreneurs (32 enterprises), university professors and researchers (3 universities of Guilan, Mazandaran, and Golestan), and policymakers and managers in Guilan, Mazandaran, and Golestan provinces, who were active in policymaking and planning of technology development, especially in the poultry industry (3 organizations of Ministry of Agriculture, State Livestock Affairs Logistics and Science and Technology Parks). The inclusion criteria for experts were having at least a bachelor's degree and at least threeyears of related experience in the poultry industry.

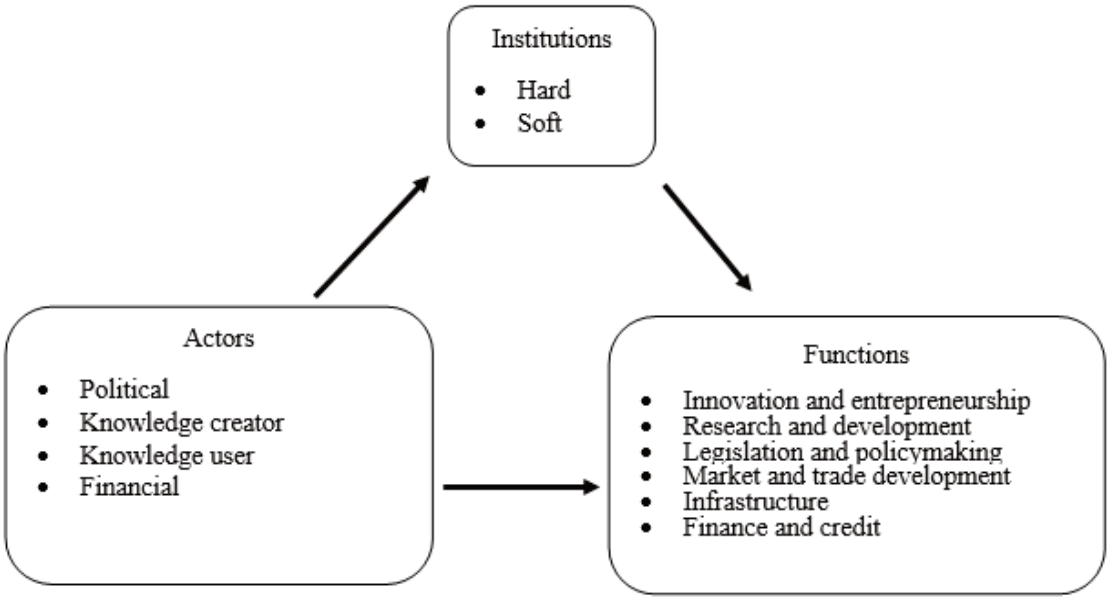


*Figure1.* Conceptual Model of Research Based on the Structural-Functional Analysis Approach

In addition to using library resources, questionnaires and interviews were also used to collect data. In this study, the structural framework of regional innovation system was selected using exploratory studies. Subsequently, semi-structured interviews with fiveexperts of the constituent indicators of the regional innovation system in the poultry industry were identified. Semi-structured interview is a type of interview where all interviewees are asked similar questions but they are free to provide their answer in any way they wish. Questions asked in the interview: 1)Which actors and institutions are responsible for the policy and implementation of the poultry industry? What is their duty? 2)Which actors and institutions are responsible for creating and disseminating knowledge in the poultry industry? What is their duty? 3)Which actors and institutions are responsible for financing the poultry industry? What is their duty? Then, two researcher-made questionnaires were designed to measure the importance of each element and were distributed among 32 experts. The first questionnaire measured the importance of structural element indicators, which included 44 questions, and the range used was a 5-point Likert scale (1 = very low to 5=very high). The second questionnaire measured the importance and performance of functional elements, which included 28 questions, and the range used to assess the importance of 5-point Likert functional elements (1= very low to 5= very high) and to measure the performance of Likert functional elements. There were 5 options (1= very poor to 5= very favorable).

Non-probability sampling method was used with the snowball technique.In the snowball technique, the interviewee is asked to introduce the next person to the researcher for interviews. This continued until interviewees introduced already-interviewed experts.Data were analyzed using SPSS and Modeler software, as well as the multi-layer perceptron artificial neural network.

The Cronbach's Coefficient Alpha and Composite Reliability (CR) were used in the Smart PLS3 software to investigate the reliability of the questionnaire and internal consistency of the items. According to various references, a minimum Cronbach's alpha and CR of 0.7 is necessary to confirm the reliability of the tool (Sanchez, 2013). Two indices were used to calculate convergent validity.The first index was Average Variance Extracted (AVE) whose values of greater than 0.5 for each variable indicate an appropriate convergent validity (Hair et.al, 2014), all of which had values greater than 0.4, (Table 3).

Table 3
*Validity and Reliability ofthe Questionnaire Components*

| Variable | Number of questions | AVE | Cronbach's alpha | CR |
|---|---|---|---|---|
| Structural elements | 44 | 0.505 | 0.944 | 0.947 |
| Innovation and entrepreneurship | 3 | 0.418 | 0.723 | 0.830 |
| Research and development | 7 | 0.479 | 0.818 | 0.865 |
| Legislation and policy-making | 5 | 0.509 | 0.762 | 0.838 |
| Market and business development | 7 | 0.512 | 0.838 | 0.879 |
| Infrastructure | 3 | 0.612 | 0.720 | 0.824 |
| Financial and credit | 3 | 0.574 | 0.740 | 0.802 |

AVE: Average Variance Extracted; CR: Composite Reliability

## RESULTS AND DISCUSSION

*Demographic analysis*: A descriptive assessment of the statistical sample showed that 84.4 percent (N=27) of the 32 subjects were male. Also, in terms of age, 53.1 percent (N=17) of the subjects were 41-50, 25percent (N=8) were 31-40, and 21.9percent (N=7) were above 50 years old.The results also showed that most people subjects (75%, N=24) had a bachelor's degree, 21.9percent (N=7) had a master's degree, and 3.1percent (N=1) had a Ph.D. The work experience analysis indicated that 46.9percent (N=15) had 21-30, 28.1 percent (N=9) had 10-20, and 25percent (N=8) had less than 10 years of experience.

*Inferential statistics results*: In order to present a poultry industry regional innovation system model, five poultry industry experts were interviewed to identify corresponding examples of the conceptual pattern. Table 4 shows the actors and institutions of the poultry industry and Table 5 shows the functions related to the poultry industry.

**1**. *What are the most important structural elements of poultry industry regional innovation?*

A multi-layer perceptron artificial neural network (ANN-MLP) was used to answer this question and identify the structural elements of poultry industry regional innovation system model. First, the validity of the generated neural network was investigated.The model related to the actors was approved by 98.8percentvalidity,indicating the homogeneity and proper fit of the developed multi-layered network.

The forecasting graph and an MLP approach were used in the next step. IRICA, Ministry of Science, Research and Technology, and Ministry of Economy and Finance had a more significant role. It should be noted, however, that all organizations were important and played a role according to the line of importance (Figure 2).

As Figure 3 shows, IRICA (as a political governmental actor) plays the most important role in innovating the poultry industry. OECD, considering great importance for the government as a political actor who sets innovation system regulation, states that the core political actors can play a significant role in shaping regional innovation processes, provided that these actors have sufficient regional independence (legal competencies and financial resources) to set up and implement innovation policies (OECD, 2009). Through tax breaks and subsidy incentives, and creating appropriate infrastructures and R&D databases, governments generally have a central role in guiding the innovation system components to interact constructively with each other (Crescenzi & Rodríguez, 2011). In an innovation system model, Guo (2010) suggested that governments and technology organizations are at the core of regional innovation systems and indicated other components including industrial companies and research, educational and financial institutions as indices that, within government activities, can lead to innovation development in the region through their interactions.

Zhao et al. (2015) also put the government at the forefront of innovation. In their model, the government is introduced as policies and rules regulator that can provide research institutions and industrial companies with policies, and allow for their interactions. Regarding the importance of government's role in innovation systems, Zhao et al. (2015) stated that in a governmental system, where almost all organizations are owned by the government, the government plays a very special role among the actors of regional innovation systems. In such systems, the government is the main cause of cooperation, with almost no interactions without governmental support and intervention.Therefore, regional innovation systems in such governmental systems defer from western governmental systems governed by regional and state governments. Trunina et al. (2019) also perceived some similarities and differences between small and medium-sized investments in technology in Chinese and US com-

Table 4
*Actors and Institutions of Poultry Industry (Structural Elements)*

| Actor | Exemplified | Institutions |
|---|---|---|
| Political | Ministry of Economic Affairs and Finance (Act1) | Developing macroeconomic and trade policies tailored to the development and formation of an innovation-based market (Inst1) |
| | Iranian National Tax Administration (Act2) | Development and implementation of tax breaks supporting innovation (Inst2)Tax breaks for research companies in the industry (Inst3) |
| | Real Estate Registration Organization (Act3) | Intellectual property protection (Inst4) |
| | Islamic Republic of Iran Customs Administration (IRICA) (Act4) | Providing exemptions for import and export tariffs (Inst5)Reducing import and export formalities (Inst6) |
| | Ministry of Science, Research and Technology (Act5) | Innovation culture and professional ethics in society (Inst7)Providing professional human resources and developing national human resources (Inst8)Establishing specialized schools in reputable universities (Inst9) |
| | Ministry of Agriculture Jihad (Act6) | Determining policies and regulations for setting up and implementing sustainable development programs (Inst10)Standards and regulations regarding the facilities and infrastructure required by production and producers (Inst11)Supporting investment development (Inst12)Adoption of supportive and motivating policies for development and promotion of machinery and equipment technology (Inst13)Arrangements and regulations related to poultry products export development (Inst14) |
| | State Livestock Affairs Logistics (Act7) | Market regulation, development, and improvement of livestock and poultry and their branches marketing, livestock and poultry feed (Inst15) |
| | Agricultural Insurance Fund (Act8) | Implementation of laws on insurance of various livestock and poultry products against natural disasters and incidental events (Inst16)Supporting producers and paying compensation (Inst17) |
| | Iran Veterinary Organization (Act9) | Providing and ensuring health of livestock products (Inst18)Providing access to global markets, sustainable development and investment in livestock sectors (Inst19)Supervising and enforcing health, quarantine and biosecurity regulations for importing, exporting and transport of livestock and livestock products (national and international) and issuing related health licenses (Inst20) |
| Knowledge creator | Mazandaran University; Islamic Azad University, Qaemshahr Branch (Act10) | An education system based on innovation culture (Inst21) |
| | Gorgan University of Agricultural Sciences and Natural Resources; Islamic Azad University, Kordkuy Branch (Act11) | |
| | Guilan University; Islamic Azad University, Rasht Branch (Act12) | |
| | Science and Technology parks (Act13) | Implementation of policies related to commercialization of research results and realization of the relationship between research, production and service sectors of the community (Inst22)Contributing to attracting technical knowledge and domestic and international capital (Inst23)Commercializing and completing a value creation chain based on academic technological capabilities (Inst24) |
| Knowledge user | Industrial companies (Act14) | Having innovation culture in products (Inst25)Entrepreneurship culture (Inst26)Risk-taking (Inst27) |
| Financial | Financial institutions (Act15) | Funding research and innovation (Inst28)Providing loans and incentive funds (Inst29) |

Table 5

*Functions and Indices of Poultry Industry (Functional Elements)*

| Functions | Indices |
|---|---|
| Innovation and entrepreneurship (Func1) | Relevance of innovations to poultry industry needs (Q1)Number of private entrepreneur companies (Q2)Provision rate of new products and services (Q3) |
| Research and development (Func2) | Number of active research centers (Q4)Long-term university-industry cooperation level (Q5)Scientific productions (articles, publications, patents) (Q6)Number of ongoing and finished research projects (Q7)Industrial or research international interactions related to the poultry industry (Q8)Access to advanced laboratory equipment (Q9)Need-based research (Q10) |
| Legislation and policymaking (Func3) | Ease of laws and regulations in poultry industry research and technology (Q11)Intellectual property laws for inventions (Q12)Emphasis on studies on poultry industry foresight (Q13)Emphasis on compliance with international production standards (Q14)Tax incentives and support (Q15) |
| Market and trade development (Func4) | Price stability (Q16)Investment risk reduction (Q17)Access to information on domestic and international markets (Q18)Potential of the export market (Q19)Clarity of customer demands (Q20)Market size (Q21)Tariff exemptions for export (Q22) |
| Infrastructure (Func5) | Strengthening infrastructures like parks, technomarket, growth centers, laboratories, and networks in poultry industry innovation research (for genetic modification, medicine and vaccine production, etc.) (Q23)Reinforcing mechanical technologies, such as machines, and equipment (Q24)Strengthening poultry sector organizations (such as cooperatives, unions, associations, etc.) as a channel for demands and support of innovation (Q25) |
| Finance and credit (Func6) | Granting innovation subsidies to activists (Q26)R&D investment (Q27)Foreign partners' investment (Q28) |

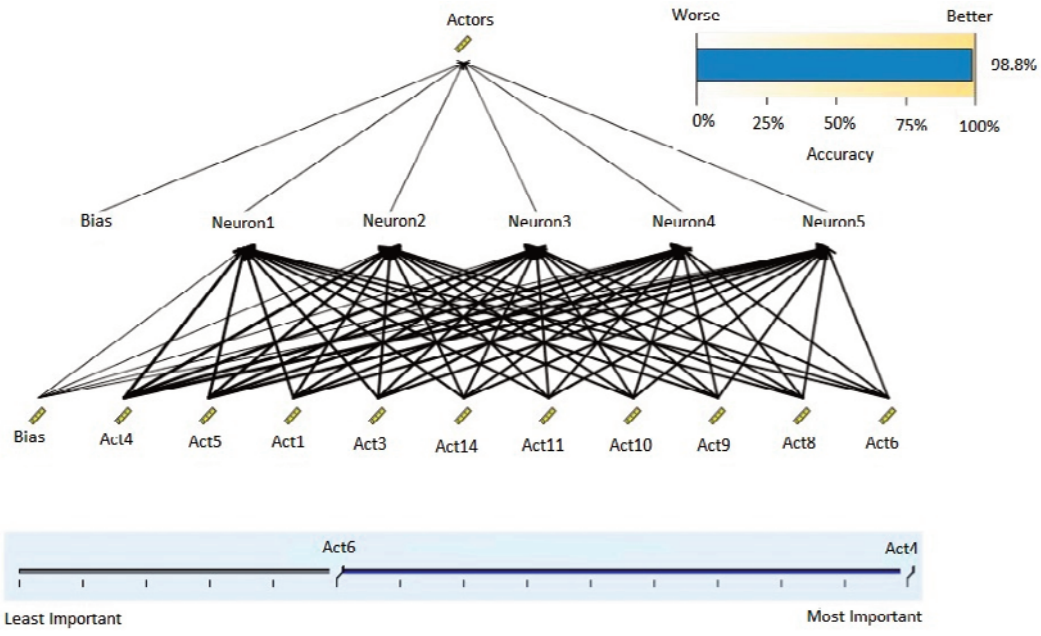


*Figure 2.* The Accuracy of the Created Neural Network for Actors

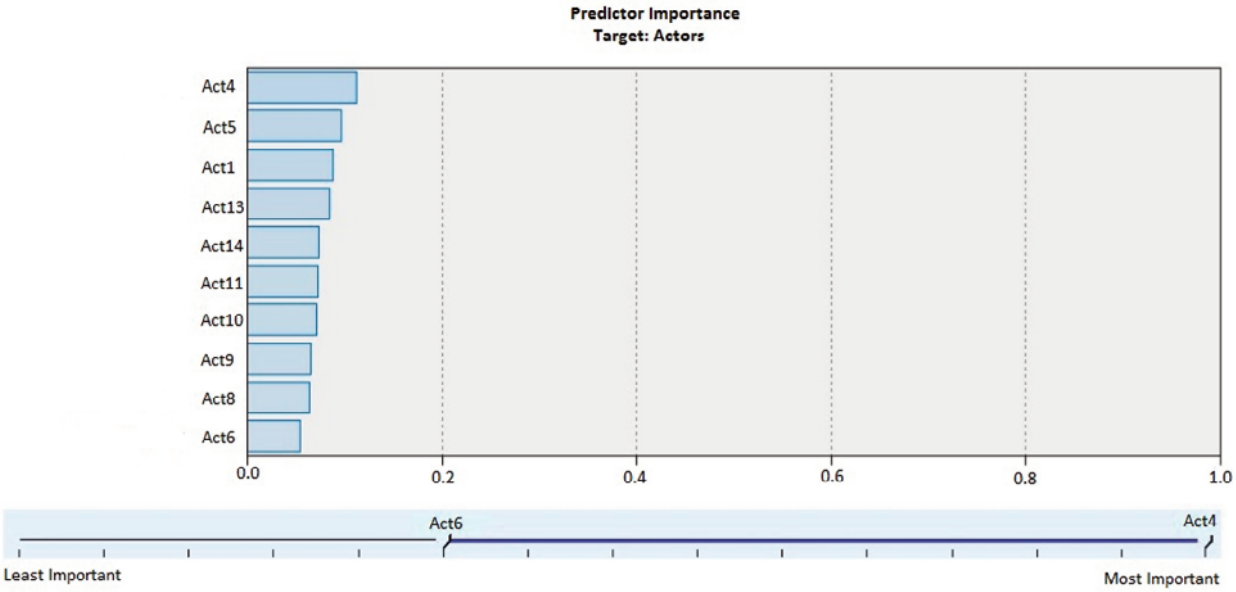


*Figure 3.* The Forecasting Graph for Actors

panies, indicating that the government was a more important business evaluator in Chinese companies. Particularly about IRICA, the government can contribute to poultry industry innovation with customs facilities, attention to technical and vocational training, compliance with standards and reforming the production structure by increasing the share of capital goods.

The validity of the created neural network for institutions was examined in Figure 4, according to which, the validityof the model and the neural network for institutions was 99.5 percent, approving the network's integrity, that is, the testing and training of the network was done correctly.

Figure 5 also shows the institutions forecasting graph with the MLP approach.

As Figure 5 shows, implementing policies to help attract domestic and international technology and capital was of paramount importance for institutions. Knowledge attraction capacity is organizations' ability to use knowledge and technology resources and is considered as a key concept in the innovation systems literature (Flatten et al., 2011; Foss et al., 2010). Cohen & Levinthal (1989-1994) suggested that technological opportunities depend on the value and amount of knowledge in the external environment. The more accessible is the available and potential knowledge for improving the performance of existing technologies, the greater is firms willingness to invest in R&D. Attracting knowledge makes the firm accurately forecast technological tendencies and take advantage of emerging technological opportunities before competitors identify them (Mohammadi et al., 2016). Organizations working on implementing knowledge-attracting policies operate under the name of science and technology parks and growth centers in Iran. According to economic theories,growth centers that are well established in an environment rich in innovation and interaction with industries and have access to resources rich in entrepreneurs, bring about greater success for the national industry. In other words, growth centers and science and technology parks are the interface to attract and transfer knowledge to the industry; hence, the focus should be on developing and improving their performance. Mian et al. (2016) stated that science and technology parks are important tools to support the innovation and growth of technology-based entrepreneurship, and

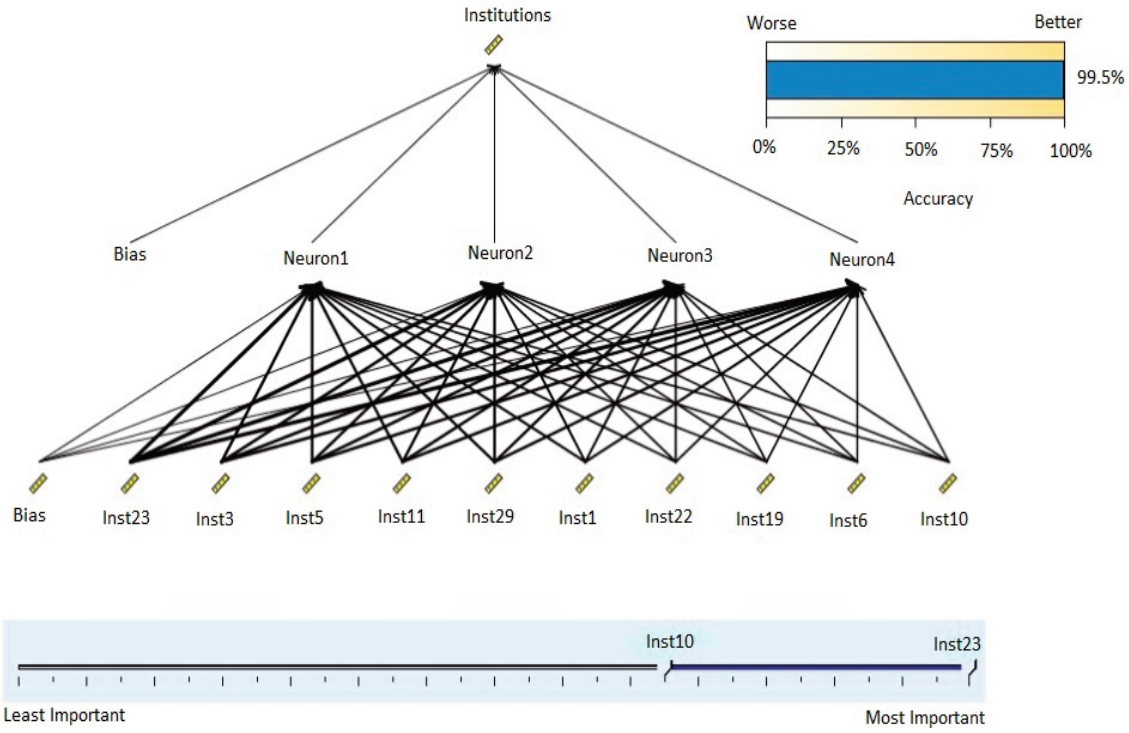


*Figure 4.* The Accuracy of the Created Neural Network for Institutions

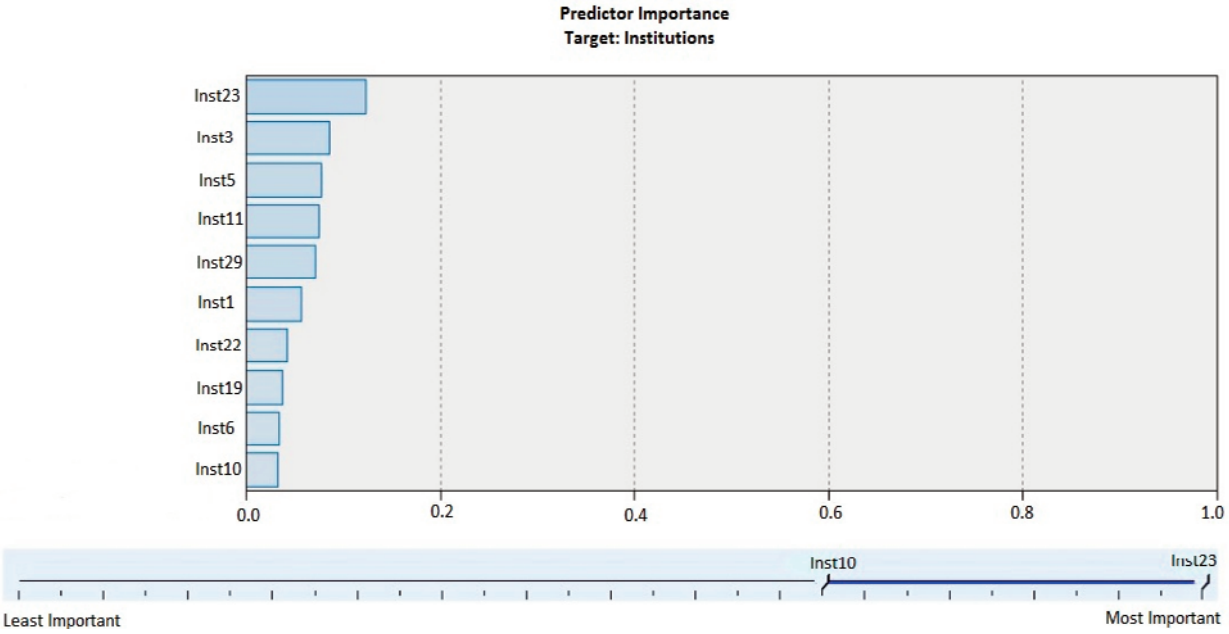


*Figure 5.* The Forecasting Graph for Institutions

they should develop to attract and transfer more knowledge.They introduced physical space, and professional management, entry and exit policy, business support and professional services, networking, access to academic capital and sources as factors affecting their development. Indicating that university development centers cannot own sophisticated physical technologies initially, Criaco et al. (2014) introduced human capital development in these centers as their main improving factor, which facilitates the implementation of knowledge attraction policies in innovation.

*2. What are the importance and performance of functional elements in the poultry industry regional innovation system?*

The IPA matrix was used to answer the research question about the regional innovation system functions. TheIPA matrix was analyzed for each of the six functions, separately. Analysis results approved the validity of the identified functions. As shown in Figure 6, the index of "relevance of innovations to poultry industry needs" had the highest importance-performance in innovation and entrepreneurship function, followed by indices of "number of private entrepreneur companies" and "provision rate of new products and services". Analysis results in this study were consistent with Maghableet al. (2017) indicating tailoring technological innovations to farmers' needs as one of the innovative and technological function indices. Vanalphenet al. (2009) also pointed to provision of new technological products and services in a study on innovative and technological function assessment. In line with this study, Suurs et al. (2010) also pointed to the entrance of companies from other areas into the field of technology.As indicated, the index of relevance of innovations to poultry industry needs had the highest importance. This indicates that policymakers should pay attention to the importance of developing innovative measures in the poultry industry based on national needs and conditions. Also, the indices of entrance of companies from other areas into the poultry industry and provision rate of new products and services had much lower performance than the other index, indicating that Iranian managers and policymakers were not able to properly attract knowledge-based companies and entrepreneurs into the poultry industry and benefit from their innovations and creativity.

According to Figure 7, the three indices of "access to advanced laboratory equipment in poultry industry", "industrial or research international interactions related to the poultry industry", and "scientific productions (articles, publications, patents)" had the highest importance-performance in the R&D function of the statistical sample, respectively. Haddad & Maldonado (2017) pointed to the number of patents in providing their functions.In line with this study, Maghableet al. (2017) suggested access to modern laboratory equipment for cruel sanctions in the research and development function. The index of "need-based research in the poultry indus-

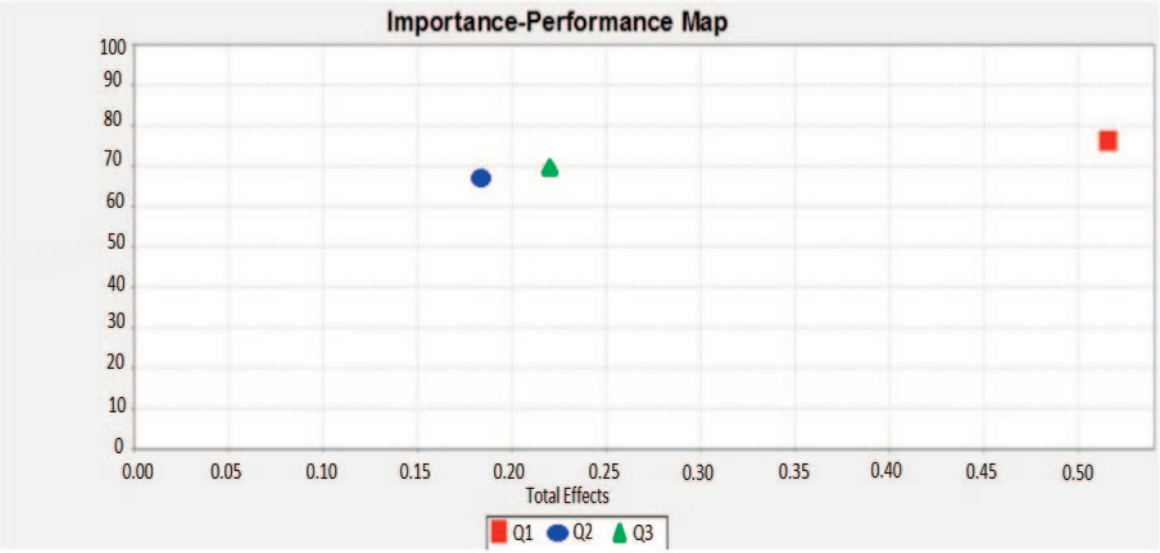


*Figure 6.* IPA Matrix Focusing on Importance-Performance of Innovation and Entrepreneurship Function

try" had the lowest performance among the R&D function indices. This means that the relationship between industry and university is not realized as needed for the poultry industry development, and academic professors and researchers are conducting research without attention to poultry industry needs. Also, due to lack of proper communication between university and industry, research findings are impractical and do not enter the industry.

According to Figure 8, two indices of "Intellectual property laws for poultry industry inventions" and "ease of laws and regulations in poultry industry research and technology" of the legislation and policymaking function had the highest importance-performance in this study. This was consistent with results presented by MeigoonPouri (2014) and Norouzi (2016) who pointed to innovation and passing laws and regulations related to intellectual property rights of inventions and innovations,

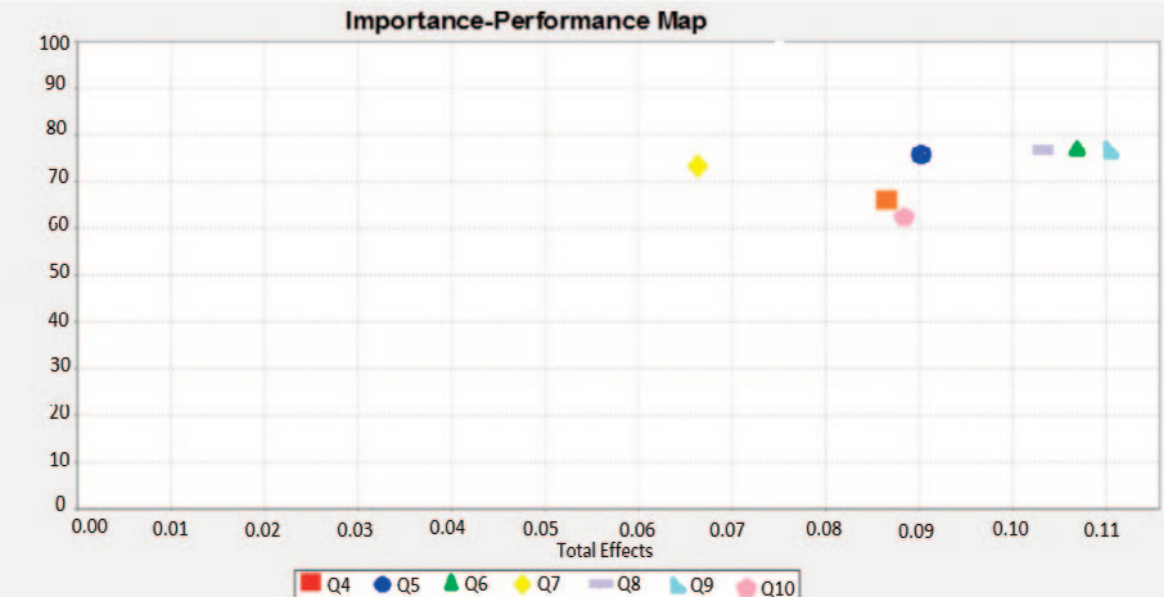


*Figure 7.* IPA Matrix Focusing on Importance-Performance of R&D Function

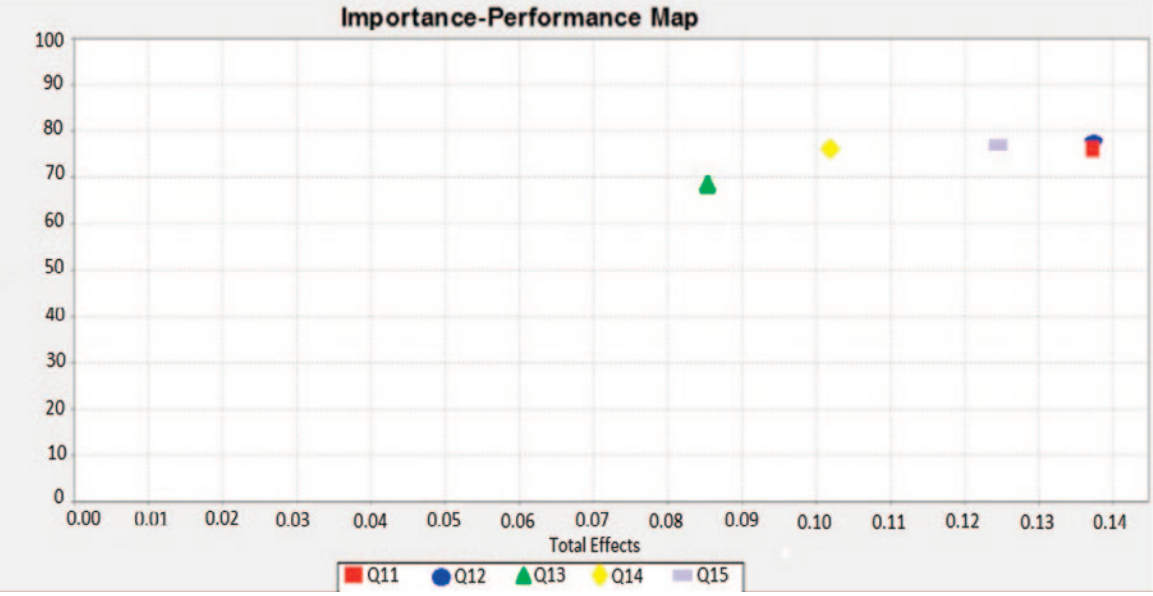


*Figure 8.* IPA Matrix Focusing on Importance-Performance of Legislation and Policymaking Function

and facilitating the rules and regulations governing R&D activities, respectively. The high performance of intellectual property laws, i.e., Real Estate Registration Organization of Iran, has been able to provide the grounds for innovations by timely passing of relevant laws and regulations and creating necessary infrastructures for protecting intellectual property rights. On the other hand, results show that the performance of "emphasis on studies on poultry industry foresight" index was lower than other indices, indicating no effective systematic efforts in the poultry industry with a long-term view in science, technology, and economy areas, necessitating further efforts in this regard.Policymakers should identify emerging trends in this industry and determine areas where investment has a higher probability of economic and social profitability for future actions.

According to Figure 9, the "poultry industry investment risk reduction" index in market and trade development had high importance. This was in line with Temel (2002) and Negro (2007) findings. Investment security in the poultry industry can be facilitated by the government.The government can motivate investment in the poultry industry by eliminating instability factors in implementation such as frequent changes in industry-related regulations, industry payments problems for taxes, premiums, customs tariffs and duties, and macroeconomic indices fluctuation consequences such as inflation and foreign exchange rates.

According to Figure 10, "strengthening infrastructures like parks, technomarkets, growth centers, laboratories, and networks in poultry industry innovation research" had the highest performance, and "strengthening poultry sector organizations (such as cooperatives, unions, associations etc.) as a channel for demands and support of innovation" had the lowest performance in the infrastructure function. These were consistent with Maghableet al. (2017). This suggests that the strengthening of infrastructures such as science and technology parks and growth centers in Iran can lead to innovation development in the poultry industry. Therefore, policymakers need to take the necessary measures to strengthen such centers.The results also indicate the low performance of poultry industry sector organizations in innovating this industry, which might be due to the low authority of these organizations to carry out innovative measures.

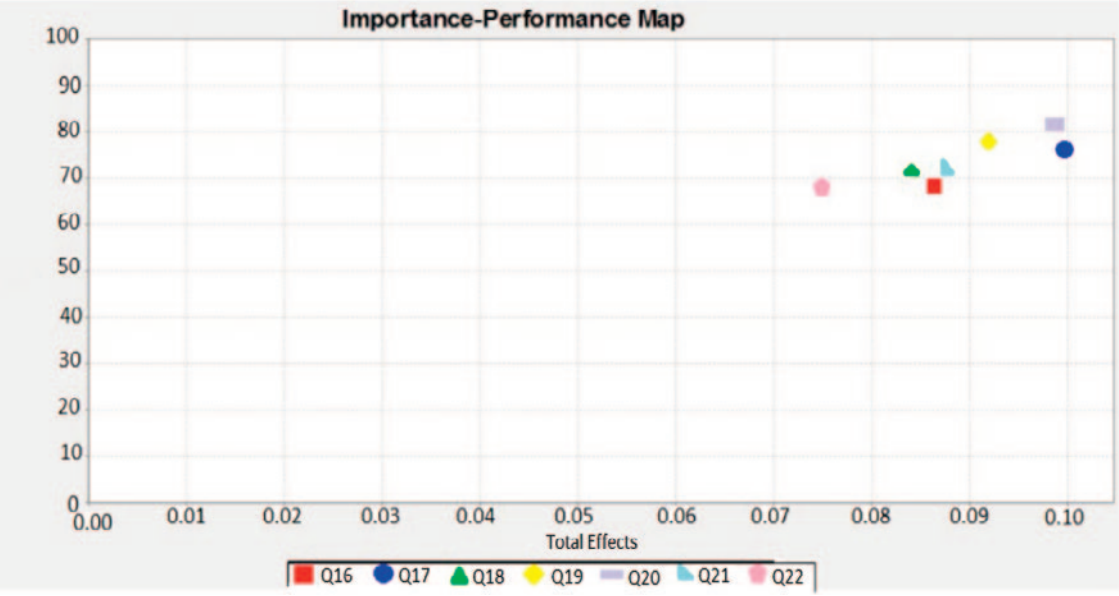


*Figure 9.* IPA Matrix Focusing on Importance-Performance of Market and Trade Development Function

Poultry industry organizations with a strong position can support producers in all sectors, especially in receiving facilities for production innovation.

According to Figure 11, the "foreign partners' investment in the poultry industry" index had the highest importancein the financial and credit function.This was consistent with the findings of Momeniand &Alizadeh (2014) pointing to government's attention to investment of firms. One of the most important steps in this regard is the elimination of multiple and wide investment risk imposed on manufacturing sectors. Issues such as increasing inflation, economic downturn, Iran's nuclear challenges in international assemblies, and unilateral sanctions against Iran have increased the risk of investment in the

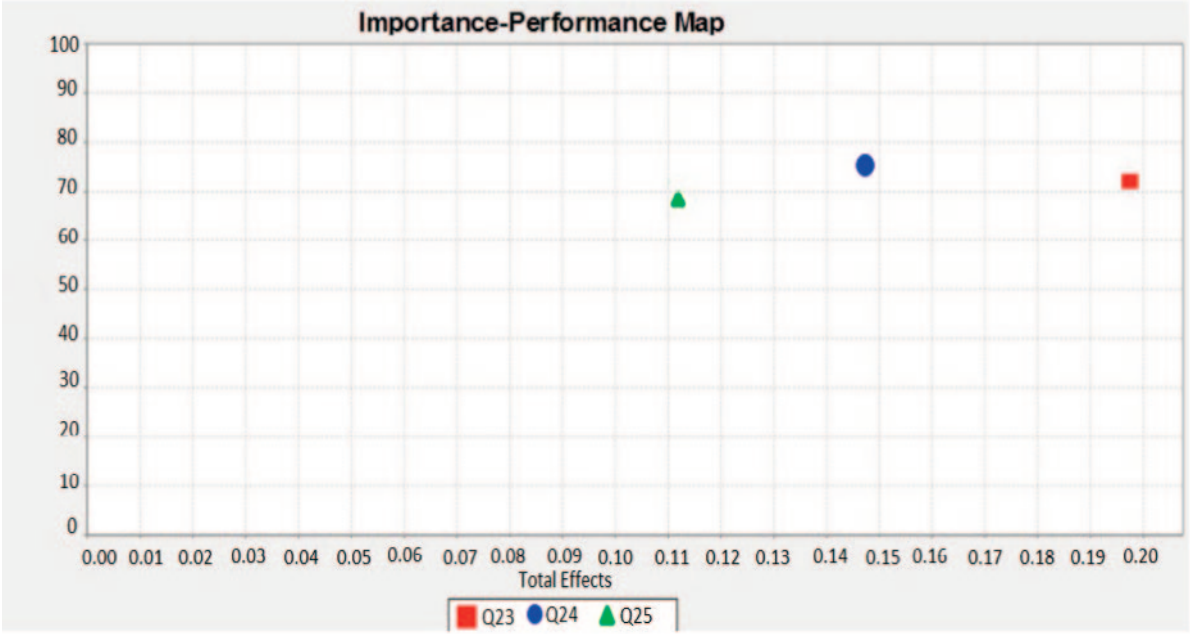


*Figure 10.* IPA Matrix Focusing on Importance-Performance of Infrastructure Function

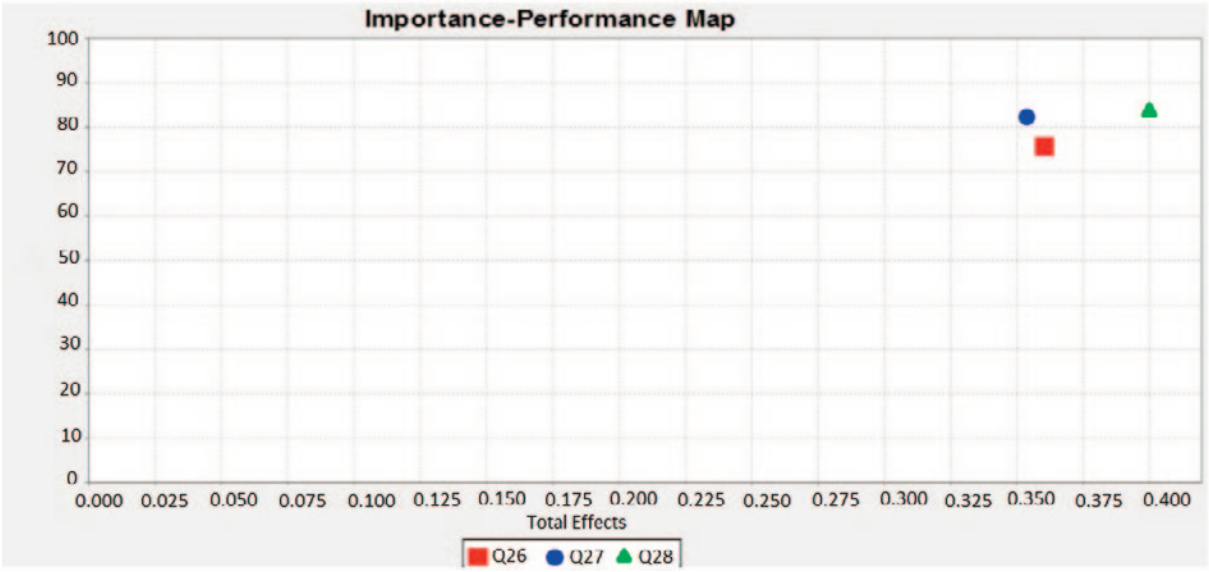


*Figure 11.* IPA Matrix Focusing on Importance-Performance of Financial and Credit Function

eyes of international institutions over the years. Policymakers need to take measures to maintain economic stability like creating peace and transparency in legal, administrative, and political systems and developing diplomatic relations with other countries.

## CONCLUSION

The concept of regional innovation system has become a used analytical framework in recent years, providing a useful empirical basis for innovation policymaking. In a region, existing industrial units are focusedsectorally and geographically, and produce and supply some goods and services by communicating and completing each other's activities, facing common challenges and opportunities.As the regional density of economic activity in a modern economic system provides the best ground for creation of an innovation-based economy, the study of regional innovation is of great importance. This study aimed to provide a poultry industry regional innovation system modeland employed the functional-structural analysis approach. This means that actors, institutions and functions or the very goals innovation system interactions were identified and analyzedat the same time. Analyses results approved the validity of indices identified through expert interviews. The findings also showed that IRICA, Ministry of Science, Research and Technology, and Ministry of Economy and Finance are the most important actors in the poultry industry regional innovation system model. Institutions associated with implementing policies to help attract domestic and international technology and investment were also more important than others. This means that the existing policies in the poultry industry should move toward using advanced knowledge and technology available in other developed countries. Analysis of the functions of the regional innovation system of the poultry industry showed that all identified indicators are approved and the interactions of the regional innovation system structures improve all the functions of innovation and entrepreneurship, R & D, legislation and policy, market development and trade, infrastructure, financial and credit.

The point about poultry industry regional innovation system analysis is that due to financial, human and even technology limitations, one cannot expect to identify all structural and functional indices associated with the system, which in turn is a limitation. In particular, the aim of this study in identifying poultry industry regional innovation system components was to identifystructures and functions for innovation considering the current industry state. These components may alter in the future. This study was based on expert surveys, while the research findings can be obtained by collecting performance data from companies or organizations associated with the poultry industry. Finally, a deeper look into the issue is recommended in further studies in order to generalize the results more confidently.

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