Designing of an open innovation model in science and technology parks

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Abstract

The main purpose of this research is to design and test an open innovation model in science and technology parks through a mixed exploratory approach. The data collection tool in the qualitative section is a semi-structured interview with 15 experts in the field of science and technology parks. Purposive sampling was used until theoretical saturation is achieved. The grounded theory was used to coding the interviews. As a result of open, axial, and selective coding in MAXQDA, 1551 free codes, 202 concepts, 73 sub-codes, and 21 main codes extracted. These codes categorized in six themes of casual conditions, central factors, strategies, contextual conditions, confounding, and outcomes. Initial questionnaire was administrated among 516 experts and managers of science and technology parks in Tehran province and affiliated companies. Confirmatory factor analyses showed high model fit with CFI equal to 0.93 and high internal consistency for the total score equal to 0.98. The results of this study showed that the proposed model of open innovation in science and technology parks in Iran has a good fit.

Keywords: Science and Technology Park, Open Innovation Model, Grounded Theory, Factor Analysis
Introduction

Open innovation is defined as the purposeful use of input knowledge with the aim of facilitating and accelerating internal innovation and utilizing output knowledge to expand it in society and use innovation (Chesbrough et al., 2006). Keupp and Gassmann (2009) also defined open innovation as the revelation and permeability of corporate organizational boundaries and the external environment. There are many benefits to using open innovation, including early participation in new technologies and job opportunities, delays in financial commitment, mitigation of losses on initial outflows, and delays in outflows if investment is possible (Vanhaverbeke et al., 2008). Open innovation also makes it possible to exploit the knowledge of smart people outside the company; it enables the simultaneous use of domestic and foreign research and development; there is no need for the researcher to invest in order to make a profit from the research; the key to success will be the best use of internal and external ideas (Docherty, 2006). Mansfield (1986) showed that innovative projects that rely heavily on external development have shorter development times and require less investment than similar projects that rely entirely on R&D. In the following years, various theories about open innovation emerged. Tushman and Anderson (1986) proposed the theory of discontinuities innovation versus fundamental innovation. According to this theory, knowledge is the main foundation of any company's ability, then any change in knowledge indicates a change in the organization's ability to provide a new service and it emphasized the organization's ability to innovate. Martins and Terblanche (2003) in their theories expressed the cultural factors influencing organizational innovation as risk acceptance, open communication between employees, ambiguity and conflict, encouraging new theories, job commitment, strong and supportive leadership, customer orientation, and increasing benefits. Baumard (2009) expressed the theory of innovation with an integrated and networked system; its most important
components are introduced as integrating development strategies between different internal and external organizations, simulation in research and development and close communication with people in the society, company flexibility to change and speed in development and more focus on quality to price (Spithoven et al., 2013).

The open innovation paradigm was first articulated by Henry Chesbrough in 2003. Chesbrough, the founder of the open innovation paradigm, identifies some of the organizational capabilities needed to move toward open innovation as follows: 1- networking and network management, 2- knowledge management, intellectual management, 3- technology monitoring, 4- market knowledge, 5- predicting market needs, and 6- product and technology planning. The goal of open innovation is to capitalize on the discoveries and innovations of others in the innovation process, as opposed to closed processes, in which companies operate only with their own professional ideas, capabilities and capacities (Schwab et al., 2013).

In Iran, in the field of open innovation development, extensive research has been done and its role in university-industry cooperation has been pointed out and research cooperation has shown a positive and significant effect on university-industry cooperation (Madhoshi et al., 2018). An open innovation model in small and medium enterprises has been designed using grounded theory (Babaei Farsani et al., 2018). In another study, the pattern of establishing open innovation in education is designed (Rashki et al., 2020). Despite extensive research in the field of open innovation in Iran, only one study has designed a model for open innovation in science and technology parks (Mirfakahredini et al., 2016) and no study has developed an instrument to measure the model. In this study, we designed, developed, and validated an instrument to measure the dimensions of the open innovation model in science and technology parks in Iran.

Methods
In this research, the exploratory mixed method has been used. Research strategy, in the qualitative phase was grounded theory with the aim of theorizing. Grounded theory is a method for constructing a theory based on facts and data (Glaser et al., 1967). The statistical population of the study includes all experts and activists in the field of science and technology parks and the sample size includes 15 of these people who were selected by purposive sampling. Preliminary data were collected through semi-structured interviews with the target population. Data collection continued until theoretical saturation was reached. Data obtained from interviews were coded through grounded theory research approach and analyzed using MAXQDA software.

In the quantitative phase, we used the developed questionnaire from the qualitative part to collect the quantitative data. The questionnaire is a five-point Likert scale and consisted of 100 items. We tested the findings acquired from the qualitative part using confirmatory factor analyses using SPSS v24 and Mplus v7.4 in a convenient sample consisting 516 participants.

Findings

Development and content validity of the questionnaire

In the qualitative phase of the research, open, axial and selective coding were used. In open coding process, the data obtained from the interviews were carefully reviewed, the main and sub themes were identified. A total of 1551 free code, 202 sub-codes, 73 main codes, and 21 dimensions were extracted. Table 3 shows the dimensions, sub-codes, and main codes extracted from the interviews.

Table 1. Dimensions, main codes, and sub-codes extracted from the interviews

| Dimensions          | Main codes                      | Sub-codes                |
|---------------------|---------------------------------|--------------------------|
| Casual conditions   | Cost and financial problems     | Cost issues              |
|                     |                                 | Financial barriers       |
|                     |                                 | Intellectual property issues |
| Central issues | Strategies | Teamwork and collective thinking | Participation and cooperation | Increase absorption capacity | Scientific and research interactions | Exhibition of achievements | Creating an innovation network | Park management specialty | Motivational factors | Contextual factors |
|----------------|------------|----------------------------------|-----------------------------|---------------------------|----------------------------------|---------------------------|-----------------------------|------------------------|----------------------|------------------|
| Lack of proper mechanisms to enforce the rules | The process of transferring knowledge and technology from outside to inside and vice versa | Team working | Academic elite participation | Ability to identify external knowledge | Interact with domestic universities | Conferences and seminars | Formal and informal communications | Technology management | Internal motivation | Development of park infrastructure |
| Rapid changes in technologies and demands | | Group thinking | Participation of community members | Ability to attract external knowledge | International interactions | Exhibitions and festivals | Network information management | Financial management | External motivation | Public Service |
| Central issues | | | | Ability to adapt external knowledge | | | | Performance management | | Patents |
| | | | | | | | | Marketing management | | |
| Provision and allocation of financial resources | Technical and specialized services |
|-----------------------------------------------|---------------------------------|
|                                               | Educational consulting services  |
|                                               | Credit facilities               |
|                                               | Allocation of financial resources|
|                                               | Facilities for attracting financial credit |
|                                               | Venture capital                 |
| Structural and content                        | Structural factors of the park  |
|                                               | Creating an open culture        |
|                                               | Park environment                |
| Development of human                          | Expert staff                    |
|                                               | Experienced partners            |
|                                               | Competitors                     |
|                                               | Partner customers               |
|                                               | Knowledge suppliers             |
|                                               | Financial investors             |
|                                               | Attract the elite               |
| Confounding conditions                        | Weakness in determining the effectiveness of the park |
|                                               | Lack of sufficient transparency |
|                                               | Complexity of park functions    |
|                                               | Uncertainty about resource      |
|                                               | efficiency                     |
|                                               | Weakness in identifying value- |
|                                               | added factors                  |
|                                               | Lack of matching plans for parks|
| Organizational constraints                    | Management factors             |
|                                               | Corporate conservatism         |
|                                               | Administrative bureaucracy      |
|                                               | Closed view of human resources |
| Outcomes                                      | The growth of the knowledge-based economy |
|                                               | Commercialize ideas             |
|                                               | Commercialize university output |
|                                               | Creating and quickly entering new markets |
|                                               | Reducing costs and risk         |
|                                               | Increasing product quality      |
|                                               | Employment                     |
|                                               | Strengthen innovative social activities |
|                                               | Increasing innovation          |
|                                               | Increasing the number of open innovators |
|                             | Strengthen the spirit of extroversion |
|-----------------------------|---------------------------------------|
| Improving cultural factors  | Improving the culture of teamwork    |
|                             | Increasing the trustability           |
|                             | Expanding the partnership participation |

In selective coding, the main variable or underlying process embedded in the data, how, its stages and consequences are plotted (Glaser et al., 1967). Based on the obtained relationships, the concepts obtained from open and axial coding were linked to each other in the selective coding stage and were reflected as a model in science and technology parks according to Figure 1. This Figure displays the relationships between dimensions in the model and how the casual conditions was led to outcomes.
After developing the open innovation model, the initial items of the Open Innovation Questionnaire of Science and Technology Parks were written. The content validity of the questionnaire was examined by an expert panel. Content analysis was performed using content validity index (Waltz & Bausell, 1981) and 9 items were removed in this phase.

**Confirmatory factor analysis**

The initial questionnaire was piloted and members of Tehran Science and Technology Park answered the questions of the questionnaire and the data were studied using confirmatory factor analyses. Kaiser-Meyer-Olkin test was performed to evaluate the adequacy of the research sample. The value obtained is equal to 0.979 which indicates that the sample size is sufficient, Table 2 shows these results.

Table 2. KMO and Bartlett test of sphericity

| Kaiser-Meyer-Olkin sampling adequacy scale | .979 |
|------------------------------------------|------|
| Bartlett test of sphericity              |      |
| Chi-Square                               | 89665.230 |
| df                                       | 4950 |
| p-value                                  | .000 |

Values above .70 indicate the adequacy of the sample size. The KMO value showed that the variance of the sample variables was sufficient for the structural validity test. In addition, the Bartlett test was significant at the level of $p=.05$. The Bartlett sphericity test measures the correlation between variables and investigates whether the variables are sufficiently correlated to perform structural validity. Therefore, the assumptions for conducting factor analysis were approved.
The matrix of components and items of the questionnaire after rotation showed that all items had a factor load greater than 0.5, so none of the items were removed (Truong & McColl, 2011). According to the developed model in qualitative phase, we tested the fit of the first and second order six-factor model solution. The results of confirmatory factor analysis in Mplus v7.4 with maximum likelihood estimation method and 20 iterations are reported in Table 3.

Table 3. Open innovation model fit for the first-order model

| Fit index                                      | value          |
|-----------------------------------------------|----------------|
| Chi-Square Test of Model Fit                  |                |
| Value                                         | 9819.180       |
| Degrees of Freedom                            | 3778           |
| P-Value                                       | 0.0000         |
| RMSEA (Root Mean Square Error of Approximation)|                |
| Estimate                                      | 0.056          |
| 90 Percent C.I.                               | 0.054-0.057    |
| CFI                                           | 0.934          |
| TLI                                           | 0.913          |
| SRMR (Standardized Root Mean Square Residual) | 0.063          |

The result of confirmatory factor analysis showed a comparative fit index equal to .934 which indicates a good fit (Kline, 2005) and the residual square root of the standardized root mean is 0.056. The RMSEA below 0.08 indicates the low error of the measurement model. The factor loadings of items in their respective factors for the first-order model are presented in supplementary files.

Second-order model solution was performed to compare it with the first-order model. This analysis also was performed using Mplus v7.4 and maximum likelihood estimation method. Table 4 shows the fit indices for the second-order model using confirmatory factor analysis.
Table 4. Open innovation model fit for the second-order model

| Fit Index                                      |       |
|-----------------------------------------------|-------|
| Value                                         | 16116.369 |
| Degrees of Freedom                           | 4697   |
| P-Value                                       | 0.0000 |

RMSEA (Root Mean Square Error of Approximation)

| Estimate | 0.069 |
| 90 Percent C.I. | 0.067-0.070 |
| CFI       | 0.875 |
| TLI       | 0.868 |

SRMR (Standardized Root Mean Square Residual)

|                |       |
|----------------|-------|
|                | 0.066 |

The comparative fit index of the model was equal to 0.875, hence, the fit indices reduced compared to the first-order model. Since, the first-order model has a better fit it was determined as the final model of open innovation questionnaire.

**Reliability**

Cronbach’s alpha was estimated as an index of reliability, it measures internal consistency of the items in their pertinent factors and indicates the correlation between items and the construct under study. Table 5 displays Cronbach's alpha values for open innovation factors and the total score.

Table 5. Cronbach’s alpha of the factors and total score

| Factors              | Cronbach’s alpha |
|----------------------|------------------|
| Casual conditions    | 0.963            |
| Central issues       | 0.973            |
| Strategies           | 0.978            |
| Contextual factors   | 0.986            |
| Confounding          | 0.971            |
| Outcomes             | 0.984            |
| Open innovation model| 0.980            |
Cronbach's alpha of the factors varies between 0.96 and 0.98 and the Cronbach's alpha of the whole questionnaire was estimated 0.98, which indicates the high internal consistency of the factors and the total score. According to the results, the open innovation model questionnaire indicated to have sufficient validity and reliability for science and technology parks in Iran.

**Discussion**

The aim of the present study was to design and test an open innovation model in Iranian science and technology parks, the mixed exploratory research approach. As a result of the qualitative part, six themes of casual conditions, central issues, strategies, contextual factors, confounding, and outcomes were extracted and the initial questionnaire was developed. Psychometric properties of the questionnaire were studied; validity of the questionnaire was measured using confirmatory factor analysis and reliability was estimated through Cronbach’s alpha. The results showed that the open innovation questionnaire for science and technology parks is a valid and reliable instrument.

In the interviews conducted in this study, the importance and usefulness of using open innovation in science and technology parks in Iran was emphasized and the interviewees mentioned many benefits for it that were reduced to sub-codes, main codes, and themes. Consistent with the findings of this study, Spithoven et al. (2013) examined the impact of open innovation on the innovative performance of small and medium enterprises compared to large firms and found that the impact of open innovation in small and medium enterprises is often different. Crema et al. (2014) also analyzed the relationship between company strategy, open innovation, and innovation performance with a focus on small and medium-sized firms and concluded that firms that follow
an innovative strategy invest more in main technical skills and competencies and companies that choose diversity strategies are more likely to choose open innovation management practices exclusively. A meta-analysis of the literature on open innovation in small and medium-sized enterprises showed that they improve their overall innovation performance by choosing open innovation. They found that a large number of studies were conducted with a quantitative approach. Surprisingly, unlike many other disciplines, North American researchers have made a limited contribution but European scientists, along with some researchers from Korea, China and developing countries, have been active in this field (Hossain & Kauranen, 2016).

Finally, the results of the present study, which was conducted with the aim of development and validation an open innovation model in Iranian science and technology parks, showed that this model is suitable for implementation in Iranian context and can measure the open innovation in science and technology parks to be used by managers, and researchers.

**Availability of data and material**

Raw data will be available upon request to the corresponding author.

**Competing interest**

All authors declare that they have no conflicts of interest.

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**Authors' contributions**
Pari Bayat conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, and together with Mehry Daraei and Amin Rahimikia authored or reviewed drafts of the paper, and approved the final draft.

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