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Measuring Innovation Culture: Validation Study of the Innovation Quotient Model and Research on a Defense Industry Firm in Turkey

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ABSTRACT

Purpose: While the innovation management literature has progressed over a wide range, culture, one of its most essential and initial parts, has been a relatively less focused area. Although there are some studies on innovation culture, there is not much consensus on how to measure innovation culture. This study has attempted to reveal what innovation culture components should be and how regional results and innovation awareness affect culture.

Methodology: This study assesses the construct validity and reliability of the Innovation Quotient instrument, which measures innovation culture in firms across the broad spectrum. The instrument's dimensions were examined, and we attempted to validate the instrument. We conducted the study on 1432 employees of a Turkish defense industry firm. The model's results were evaluated, and the model's new structure was presented.

Findings: We reached three main points: 1. The cultural structure and regional innovation ecosystem affect the measurement of innovation culture 2. A firm's lack of a corporate innovation system prevents some questions about innovation culture from being understood 3. To measure innovation culture in firms, cultural indicators such as the behavior of managers, the working climate, and values should be considered initially rather than the input, output, or performance indicators of innovation.

Practical implications: The findings of our study indicate some implications for managers regarding the importance of innovation culture. These validated study outputs offer managers a way and attitude to initiate innovation. It also analyzes the current situation and supports managers in overcoming their shortcomings. It shows the areas that need to be focused on to make their organizational structures more agile and innovative.

Originality: Various measures and dimensions of an innovation culture have emerged in recent decades. However, there is inconsistency regarding the number and content of the dimensions across various measures of culture. However, the validity and reliability of most of these measurements have not been tested. This study fills the literature gap by analyzing a frequently used scale to reveal what an innovation culture scale should consist of.

Keywords: Corporate Innovation, Culture, Innovation, Innovation Culture, Organizational Culture

JEL Codes: M14, O30, O31

İnovasyon Kültürünün Ölçümlenmesi: İnovasyon Quotient Modelinin Doğrulanması ve Türkiye'deki Bir Savunma Sanayi Firmasında Uygulanması

Amaç: İnovasyon yönetimi literatürü geniş bir yelpazede ilerlerken, en temel ve başlangıç parçalarından biri olan kültür, nispeten daha az odaklanılan bir alan olmuştur. İnovasyon kültürü üzerine bazı çalışmalar olsa da inovasyon kültürünün ölçülmesi konusunda çok fazla fikir birliği bulunmamaktadır. Bu çalışma, inovasyon kültürü bileşenlerinin neler olması gerektiğini ve bölgesel sonuçların ve inovasyon bilincinin kültürü nasıl etkilediğini ortaya koymaya çalışmıştır.

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Metodoloji: Bu çalışma, geniş bir yelpazedeki firmalarda inovasyon kültürünü ölçen Innovation Quotient enstrümanının yapı geçerliliğini ve güvenilirliğini değerlendirmektedir. Enstrümanın boyutları incelenmiş ve enstrümanın geçerliliği sağlanmaya çalışılmıştır. Ölçeği bir Türk savunma sanayi firmasının 1432 çalışanı üzerinde uygulandı. Modelin sonuçları değerlendirildi ve modelin yeni yapısı sunuldu.

Bulgular: Çalışma sonucunda üç ana noktaya ulaştık: 1. Kültürel yapı ve bölgesel inovasyon ekosistemi inovasyon kültürünün ölçümünü etkilemektedir 2. Bir firmanın kurumsal inovasyon sisteminin olmaması, inovasyon kültürü ile ilgili bazı soruların anlaşılmasını engellemektedir. Firmalarda inovasyon kültürünü ölçmek için inovasyonun girdi, çıktı veya performans göstergelerinden ziyade yöneticilerin davranışları, çalışma iklimi ve değerler gibi kültürel göstergeler öncelikle dikkate alınmalıdır.

Pratik çıkarımlar: Çalışmamızın bulguları, yöneticiler için inovasyon kültürünün önemine ilişkin bazı çıkarımlara işaret etmektedir. Doğrulanan bu çalışma çıktıları, yöneticilere inovasyonu başlatmak için bir yol ve tutum sunmaktadır. Ayrıca mevcut durumu analiz etmekte ve yöneticilere eksikliklerinin üstesinden gelmeleri konusunda destek olmaktadır. Organizasyonel yapılarını daha çevik ve yenilikçi hale getirmek için odaklanılması gereken alanları göstermektedir.

Özgünlük: Geçtiğimiz on yıllarda inovasyon kültürüne ilişkin çeşitli ölçütler ve boyutlar ortaya çıkmıştır. Bununla birlikte, kültürün çeşitli ölçümleri arasında boyutların sayısı ve içeriği konusunda tutarsızlık vardır. Öte yandan, bu ölçümlerin çoğunun geçerliliği ve güvenilirliği test edilmemiştir. Bu çalışma, bir inovasyon kültürü ölçeğinin nelerden oluşması gerektiğini ortaya koymak için sık kullanılan bir ölçeği analiz ederek literatürdeki boşluğu doldurmaktadır.

Anahtar Kelimeler: Kurumsal İnovasyon, Kültür, İnovasyon, İnovasyon Kültürü, Organizasyon Kültürü

JEL Kodları: M14, O30, O31

1. Introduction

Culture is a structure that concerns people with its organizational, national, and social aspects. In other words, culture is the value structures of people in a specific region, their characteristics, and a set of values that encompass their behavior (Akkaş, 2022). In a broad sense, organizational culture refers to shared values and views among employees regarding the organization's existence, purpose, and mission (Zanjirchi, Jalilian, and Mehrjardi, 2019). Therefore, organizational culture forms the foundations of systems that establish the management principles that should be followed (Tian et al., 2018).

There is no consensus on the definition of organizational culture. Early descriptions of organizational culture are based on emotional and cognitive aspects with core managerial concerns (Kondra and Hurst, 2009). Nevertheless, most studies agree that organizations should have common thoughts (Schein, 2010). These are typically described as the values, norms, attitudes, and behavioral patterns that make up an organization's or sub-units most valuable asset (Olmos-Peñuela et al., 2017).

Firms need a culture that recognizes innovation and tolerates failure based on strong shared values and beliefs to facilitate innovation (Büschgens, Bausch, and Balkin, 2013). This organizational culture paves the way from organizational culture to innovation culture (Jin, Navare, and Lynch, 2019). Organizational

culture can also be characterized as the center of an organization's innovative activity. This culture is shaped by new ideas created, valued, and supported. Innovation culture can be influenced by organizational culture, and it may become more prevalent or uncommon in some parts of the organization. Organizational culture encourages creativity and originality through innovation culture. In this manner, both cultures correlate and support each other (Sharifirad and Ataei, 2012; Abdul-Halim et al., 2019).

Constructs of innovation and culture might emerge in different ways in different organizations. Therefore, different definitions of innovation culture are encountered in the literature. Herzog and Leker (2010) described innovation culture in three components in their study of how a good innovation culture should implement open and closed innovation initiatives. The components can be summarized as organizational-wide shared core values that encourage innovation, organizational-wide norms for innovation, and perceptible innovation-driven studies. In another study, innovation culture is defined by considering marketing strategies. Innovation culture is defined as the tendency of organizations to improve themselves by identifying the differences between a constant learning structure and the demands of the market and what the market currently offers (Brettel and Cleven, 2011). Hofstede (2016) defines innovation culture as an attitude toward technology, information exchange, entrepreneurial activities, and uncertainty. Jin, Navare, and Lynch (2019) describe innovation culture as an environment that is open to innovation, a mindset that can create change and future-oriented marketplaces, and a set of shared values and behaviors that are willing to take chances and continue to learn. Innovation culture supports innovative thinking, development, and perceived applications toward innovation. Innovation culture is not stationary and changes over time. For this reason, creativity, learning, thinking, and communication should be encouraged, thereby building an innovation-driven culture with an innovation-based culture (Liu and Fellows, 2012).

Various measures and dimensions of innovation culture have emerged in the past decades (Aiman-Smith et al., 2005; Dombrowski et al., 2007; Dobni, 2008; Rao and Weintraub, 2013; Villaluz and Hechanova, 2019). However, there is inconsistency regarding the number and content of the dimensions across various measures of culture (Michaelis, Aladin, and Pollack, 2018). For example, Dombrowski et al. (2007) developed eight dimensions: 1. Innovative mission and value statements 2. Democratic communication 3. Safe space 4. Flexibility 5.

Boundary spanning 6. Collaboration 7. Incentive 8. Leadership 9. Sustainability. Dobni (2008) empirically identified seven components of innovation culture: 1. The implementation context 2. Organizational constituency 3. Organizational learning 4. Market orientation 5. Innovation propensity 6. Value orientation 7. Employee creativity and empowerment. Rao and Weintraub (2013) exhibited an innovation culture model named the Innovation Quotient instrument, which comprises six dimensions: 1. Values 2. Resources 3. Behaviors 4. Processes 5. Climate and 6. Success. (Villaluz and Hechanova, 2019) analyzed six dimensions to measure innovation culture: 1. Role modeling and leadership support for innovation 2. Communicating strategy for innovation 3. Employee engagement and climate 4. Support system and structures. 5. Training and development for innovation 6. Evaluation and rewards.

This study assesses the construct validity and reliability of the Innovation Quotient instrument (Rao and Weintraub, 2013). There are four primary purposes for choosing this instrument (Sarıgül and Çubukcu, 2021): 1. This is one of the most recent and comprehensive studies. 2. Many other studies have mainly focused on performance and output indicators in addition to cultural dimensions such as behavior, climate, and values. This creates uncertainty about what to measure. 3. Few studies have been conducted on its validity. 4. The existing innovation culture literature links and supports (Rao and Weintraub, 2013) six building blocks (values, resources, behaviors, processes, climate, and success), as expressed in detail in the next section.

Many studies have measured innovation performance and evaluated innovation outputs (Brenner and Broekel, 2011; Frank et al., 2016; Janger et al., 2017; Saunila, 2017; Bican and Brem, 2020; Ponta, Puliga, and Manzini, 2021). The relationship between innovation culture and firm performance (Öğüt and Tarhan, 2022) and innovation performance (Ghasemzadeh et al., 2019; Hanifah et al., 2019) is also clear in some studies. Nevertheless, the innovation management literature progresses in a wide range, and culture, one of its most essential parts, has been a relatively less focused area. It is impossible for a firm that is not culturally ready to innovate to succeed in sustaining innovation. Making a firm culturally ready for innovation is the most critical initial stage of corporate innovation management practices. To reveal the cultural innovation postures of these companies, this study was conducted, and an innovation culture model validated from our perspective was presented.

2. Literature Review

Culture should be considered the main requirement for performing innovations, not an important asset. Firms must have a set of organizational-wide shared beliefs and understandings to achieve sustaining innovations (Sharifirad and Ataei, 2012). While a conservative culture reduces innovation opportunities, an innovation-oriented organizational culture improves innovative performance in firms (Al-Khatib et al., 2021). We can also see that the organizational characteristics of innovative firms differ from those of non-innovative companies (Subramanian, 1996). At this point, we realize that culture is a triggering mechanism for innovation. For instance, Jin, Navare, and Lynch (2019) analyzed that innovation culture positively correlates with innovation outcomes. Many studies have also demonstrated that innovation culture is related to organizational performance (Dombrowski et al., 2007; O'Connor, 2008; Cameron and Quinn, 2011; Büschgens, Bausch and Balkin, 2013; Shahzad, Xiu and Shahbaz, 2017) and new product development (Cooper and Kleinschmidt, 1995; Michaelis, Aladin and Pollack, 2018). In parallel, Martín-de Castro et al. (2013) examined that the most significant effects on product innovation are human capital, innovation culture, and technological knowledge assets.

Some researchers have developed measures to understand the innovative firm culture (Aiman-Smith et al., 2005; Dombrowski et al., 2007; Dobni, 2008; Rao and Weintraub, 2013; Villaluz and Hechanova, 2019), and some validated (Dobni, 2008) 's study (Dobni, 2008; Sharifirad and Ataei, 2012) and (Danks, Rao and Allen, 2017) validated Rao and Weintraub (2013) 's Innovation Quotient instrument study. Some authors also used different instruments to measure and validate innovation culture (Brettel and Cleven, 2011; Chen, 2011).

We assessed the construct validity and reliability of the Innovation Quotient instrument (Rao and Weintraub, 2013). We discovered that this structure focuses more on cultural and innovative values. In addition, we found only one study, published in two parts, on its validity (Danks, Rao, and Allen, 2017). Rao and Weintraub (2013) presented an innovation culture model that consists of six building blocks (Figure 1): resources, processes, values, behavior, climate, and success. They designed a survey of around 54 items on a scale of 1 to 5 under these blocks to enable managers to assess the innovation culture of firms. They asserted that their model builds upon dozens of studies by numerous authors. Alongside, we found many studies that prove this block structure as follows:

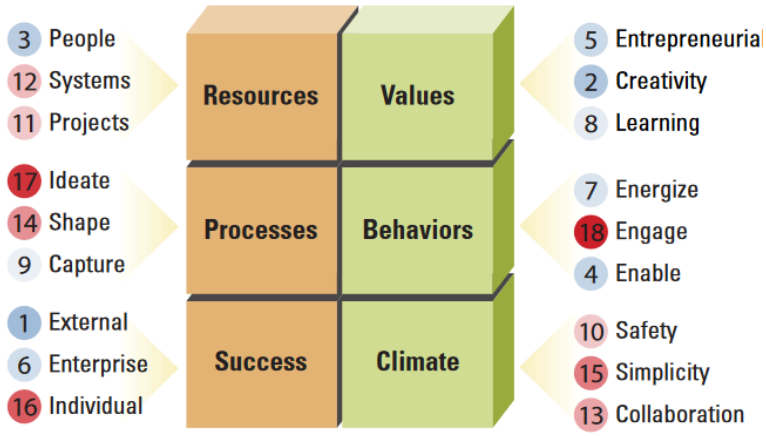


Figure 1. (Rao and Weintraub, 2013) Innovation Quotient Instrument

2.1. Values

Values are directly related to the degree of recognition in the market as an innovative firm that is open and tolerant of uncertainty and failure, action-oriented, creatively oriented, and has a learning culture. Michaelis, Aladin, and Pollack (2018) define "innovation culture" "as the values, beliefs, assumptions, and symbols in an entrepreneurial venture that facilitates activities. Dobni (2008) pointed out that "an innovation culture has been defined as a multi-dimensional context, which includes the intention to be innovative, the infrastructure to contribute to innovation, operational behaviors to influence a market and value orientation, and the environment to implement." Martín-de Castro et al. (2013) defined innovation culture as sharing common values, beliefs, and assumptions among employees. It is also found that the synthesis of creativity and innovation with a firm's values contributes to an innovative culture (Lendel and Varmus, 2011).

2.2. Resources

Resources comprise three main factors: people, systems, and projects. If we examine the existence of innovation culture from the dimension of resources, the following components should exist: 1. There must be labor resources, both internally and externally, devoted to innovation. 2. There should be well-designed collaboration mechanisms with stakeholder. It is necessary to allocate resources to capture new opportunities. Innovation requires the presence of organizational

structures, systems, resources, and time for new and added-value projects (Villaluz and Hechanova, 2019). Most of them are also related to innovative firm culture. Kratzer et.al. (2017) found that company innovation culture comes in five primary forms, most of which are directly related to resources: closed innovation (driven by internal capabilities); doing, using, and interacting (ad hoc processes, no link to knowledge providers); outsourcing innovation capabilities; extramural innovation, no matching internal culture/procedures, and proactive innovation. Although it is not always correct to say that innovation succeeds with more resources allocated to innovation activities, it is crucial to balance internal and external resources and to be aware of open innovation opportunities to create an innovative firm culture.

2.3. Climate

Climate refers to an organizational environment that includes the degree of business bureaucracy, flexibility in working conditions, and the degree of cooperation and communication among employees (Glisson, 2015). Organizational culture turns to innovation culture when an organizational climate encourages employees' innovation capacity, tolerates risk, and supports employees' growth and development (Martín-de Castro et al., 2013). An innovation culture allows employees to be involved in firms' decision-making by encouraging them to openly communicate and share their opinions and ideas (Akgün, Keskin, and Byrne, 2010). This process encourages shared ideas among employees, social interactions, and knowledge sharing, which are likely to develop an innovative organizational climate (Ma et al., 2021).

2.4. Behaviors

Organizational culture is strongly associated with employee behavior and attitudes (Kratzer, Meissner, and Roud, 2017). Behavior indicates the habits of people and how they act to be innovative. The synergy between employees, managers' behavior as servant leaders, and the degree of employee initiative are the main topics of the behavior dimension of an innovation culture. Innovation culture is a medium between management and organizational behavior (Ma et al., 2021). It is more related to the organizational climate and employees' innovative behavior, including those of managers and leaders, rather than an organizational process (Sattayaraksa and Boon-itt, 2016).

Some studies directly associate behavior with innovation. Harkema (2003) stated that innovation is adopting an idea or behavior new to the organization. Damanpour (1991) thinks that innovation is beyond behavior and activities. Santos-Vijande and Álvarez-González (2007) express that "an innovative firm must be embedded in a strong culture that stimulates engagement in innovative behavior."

2.5. Processes

Processes describe the innovation process. The existence of systematic idea-gathering and idea-management systems, the ability to evaluate and implement ideas, and the ability to commercialize new ideas are the stages of these processes. Therefore, one of the other main components of an innovative culture is fuzzy front-end innovation processes and infrastructure to implement innovation, which describes the innovation funnel in addition to behavior and other components (Al-Khatib et al., 2021). The existence of an effective innovation process contributes to the innovation performance of firms and their innovative firm culture. Innovation culture depicts the firm's willingness to try out new and added-value ideas and openness to radical and disruptive change (Villaluz and Hechanova, 2019). In addition, the innovative firm culture encourages employees to seek new ideas and try different project idea alternatives that might be an input for the new product development process (Sattayaraksa and Boon-itt, 2016). This process encourages shared ideas among employees, social interactions, and knowledge sharing (Ma et al., 2021), which also constitute idea maturing and organizational learning.

2.6. Success

Success starts with external recognition, which shows how well stakeholders are innovating a company and whether an innovation has paid off financially (Rao and Weintraub, 2013). Success triggers the firm's values, behaviors, and processes, which in turn drive many subsequent actions and decisions, such as the consideration of innovation activities more strategically and rewarding and sustaining innovation activities (Rao and Weintraub, 2013). This view has also been demonstrated by Al-Khatib et al. (2021). They found that an innovative culture could improve innovative performance.

3. Methodology

This study adapts the implementation of the "Innovation Quotient Instrument" developed by Rao and Weintraub (2013) to a large defense industry firm in Turkey. First, exploratory factor analysis was used to reveal the structural validity of the scale. Then, the accuracy of the structure determined by confirmatory factor analysis was revealed. The following processes (Figure 2) were applied to adapt the Institutional Innovation Culture Scale.

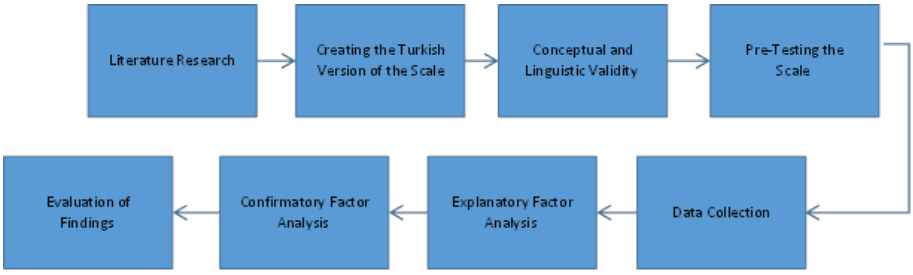


Figure 2. Research Process

3.1. Data Collection Tool

The Innovation Quotient Instrument consists of 6 dimensions and 54 items that assess participants' perceptions of the organization and innovation culture. The questionnaire form consists of two parts. The first part consists of demographic/multiple choice questions, and the second part consists of Likert scale questions. The six interdependent sub-areas that measure innovation culture are expressed above as values, behaviors, climate, resources, processes, and success.

This study used the scale developed by Rao and Weintraub (2013) for Corporate Innovation Culture. This scale was applied in 13 countries (Spain, Chile, Colombia, USA, Panama, El Salvador, Portugal, Mexico, Germany, Scotland, England, Saudi Arabia, and Belgium) (Rao and Weintraub, 2013).

A survey form was prepared, and data collection was carried out within the firm's database. A total of 1613 employees from the technician, worker, engineer, and managerial levels participated in the study. Of those who participated in the survey, 57% were employees at the engineering level. After the data extraction processes, it was determined that 1432 employees completed the questionnaire, and study findings and analyses were carried out on this sample.

3.2. Analysis Methods

The primary purpose of this research is to make a Turkish adaptation of the Corporate Innovation Culture Scale, which is widely used internationally. For this purpose, exploratory factor analysis was performed to test the structural validity and reliability of the scale, and the confirmatory factor analysis model was created. Before testing the research scale model, validity and reliability analyses were applied to the scales used in the research. Factor analyses were used to determine validity. Cronbach's alpha coefficients were used for scale reliability. In addition, to provide conceptual validity, the scale was presented to the opinions of 3 academicians who are experts in the field. To ensure language compatibility, the opinions of a linguist and an academic expert were collected, and the Turkish version of the scale was given its final version. The analysis methods used in this research can be explained as follows.

3.2.1. Exploratory Factor Analysis (EFA)

Exploratory factor analysis (EFA) is a common technique used to reveal relatively independently consistent subsets of variables in a dataset. In this analysis, variables that are related to each other but independent of other subsets are combined as "factors." To measure a concept, a set of variables consisting of many items is measured. Factor analysis examines the concepts measured and the correlations between the items used to measure these concepts. These correlations reveal the correlation patterns between the variables. Factor analysis is used to summarize the correlation patterns in observed variables designed for specific purposes, to reduce many variables to a smaller number of factors, to identify the equation variables that make up the research equations, and to test a theory. Exploratory factor analysis (EFA) is a pioneering analysis often used to combine variables and generate hypotheses about key measurement processes. In the exploratory factor analysis, the Bartlett test of sphericity is used to test the compatibility of the dataset for analysis. The factor loadings of the variables and factor explanation ratios are determined by subjecting the data whose suitability is tested to factor analysis. Finally, the number of factors constituting the measured concept and the variables constituting the factor is determined. CFA, on the other hand, is a much more complex process used to test a theory about implicit processes. CFA is generally used for structural equation modeling (Tabachnick and Fidell, 2015).

3.2.2. Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) provides excellent convenience regarding measurement models and enables the development of these models. This analysis provides a latent variable (factor) formation for the observed variables through a model established based on research (Yaşlıoğlu, 2017). In this study, confirmatory factor analysis (CFA) was performed to understand the scale's suitability for the main factor structure and, if appropriate, the degree of suitability.

The fit indices obtained by confirmatory factor analysis were as follows: Chi-square Fit Index (χ2/SD), Root Mean Square Errors of Approximation (RMSEA), Goodness of Fit Index (GFI), Unnormed Fit Index (NFI), Comparative Fit Index (CFI), Adjusted Goodness of Fit Index (AGFI), Unnormed Fit Index Index (NNFI), Incremental Fit Index (IFI), Strict Normized Fit Index (PNFI), Strict Goodness of Fit Index (PGFI), Root Mean Square Errors (RMR), Akaike Information Criterion (AIC), Consistent Akaike Information Criterion (CAIC), and Expected Cross Validation Index (ECVI). The most taken consideration among these fit indices is the values obtained from the CMIN (χ2/SD), CFI, GFI, and RMSEA tests (Gergerlioğlu, 2020).

Good fit and acceptable fit values for these fit indices are as follows (Schermelleh-Engel, Moosbrugger, and Müller, 2003):

- X2/df= $0 < \chi 2/df \leq 2$, good fit; $2 < \chi 2/df \leq 3$, acceptable fit
- RMSEA = $0 \leq RMSEA \leq 0.05$, good fit; $0.05 < RMSEA \leq 0.10$ acceptable fit
- GFI = $0.95 \leq GFI \leq 1$, good fit; $0.90 \leq GFI < 0.95$ acceptable fit
- CFI = $0.95 \leq CFI \leq 1.00$, good fit; $0.90 \leq CFI < 0.95$, acceptable fit

To ensure data validity and reliability, several studies have been conducted to provide conceptual validity, apart from factor analysis that tests the model structure. In our study, exploratory and confirmatory factor analysis techniques were used to adapt the scale. Additionally, Cronbach's alpha values were used to test the reliability of the resulting dimensions and scale. First, language validity was tested using translation and re-translation methods. Then, opinions on conceptual validity were obtained from experts in the field. Finally, the statistical reliability of the data was tested in a pilot study.

3.2.3. Exploratory factor analysis (EFA) results

Exploratory factor analysis was performed to determine the construct validity of the scale. The Kaiser–Mayer–Olkin (KMO) test and Bartlett sphericity test were used to evaluate whether they were suitable for the given factor analysis. According to the analysis results, the KMO value of the Innovation Quotient Instrument was 0.99, the Barttlet Sphericity Test Chi-Square value was 89220.510, and the p-value was 0.000. Accordingly, the data collected with the instrument show that sample adequacy is provided, and these data are suitable for factor analysis.

Table 1. EFA Factor Loads of Dimensions in the Innovation Quotient Instrument

Factor	Method	Items										
Factor 1	EFA	Q43	Q36	Q44	Q45	Q34	Q42	Q40	Q54	Q32	Q41	Q27
		0,714	0,689	0,673	0,668	0,667	0,665	0,642	0,634	0,624	0,617	0,516
	EFA	Q29	Q33	Q39	Q35	Q38	Q25	Q31	Q19	Q37	Q52	
		0,612	0,609	0,605	0,597	0,595	0,591	0,579	0,542	0,538	0,468	
Factor 2	EFA	Q12	Q11	Q10	Q16	Q18	Q13	Q15	Q17	Q14	Q28	
		0,780	0,771	0,761	0,757	0,756	0,750	0,740	0,686	0,536	0,519	
Factor 3	EFA	Q47	Q48	Q46	Q49	Q51	Q50	Q53	Q30			
		0,753	0,733	0,686	0,642	0,580	0,568	0,507	0,424			
Factor 4	EFA	Q2	Q3	Q1	Q9	Q6	Q8	Q5	Q4			
		0,708	0,689	0,611	0,591	0,556	0,534	0,525	0,611			
Factor 5	EFA	Q23	Q22	Q26	Q21	Q24	Q20	Q7				
		0,640	0,615	0,588	0,560	0,559	0,536	0,530				

** KMO Value=0.988; Bartlett Test of Sphericity Chi-Square=89220.510; df=14.31; p=0.000*

*** Total variance explained 73,767%*

****Factor extraction method: Principal component analysis; Rotation method: Varimax*

***** Q1-Q54: 54 items on the scale*

Varimax and principal components were used as rotation methods in the exploratory factor analysis. After the analysis, five dimensions with an eigenvalue more significant than one and explaining 73% of the total variance were identified.

The factor loads of the instrument, which consists of 54 items, are between 0.78 and 0.47. The factor loads in the Institutional Innovation Culture Instrument were calculated as follows:

- The factor loads of Factor 1 (21 items) varied between 0.71 and 0.47
- The factor loads of Factor 2 (10 items) varied between 0.78 and 0.52
- The factor loads of Factor 3 (8 items) varied between 0.75 and 0.42
- The factor loads of Factor 4 (8 items) varied between 0.71 and 0.61
- The factor loads of Factor 5 (7 items) varied between 0.64 and 0.53

While the origin of the scale consists of 6 factors, the scale decreased to 5 factors in the results of our analysis. When we sift through Table 1, we see that the items in the resource dimension are generally distributed in other dimensions, especially in the process dimension. In the origin structure, the first nine items (Q1-Q9) are under the values dimension; the second 9 items (Q10-Q18) are under the behaviors dimension; the third nine items (Q19-Q27) are under the climate dimension; the fourth nine items (Q28 - Q36) are under the resources dimension; the fifth nine items (Q37-Q45) are under the processes dimension; and the last and sixth nine items(Q46-Q54) are under the success dimension.

3.2.4. Reliability Test Results

Reliability analysis was performed on the dimensions of the innovation quotient instrument. An average α value was obtained for the five dimensions of the scale. The average α value for the dimensions should be 0.70 or greater than 0.70 (Kilic, 2016). Cronbach's alpha values, which show the total reliability of each scale, are examined (Table 2). Cronbach's alpha values for the factors were calculated as follows: the value of Factor 1 (21 items) is 0.978, that of Factor 2 (10 items) is 0.968, that of Factor 3 (8 items) is 0.950, and that of Factor 4 (8 items) is 0.930. Factor 5 The value of (7 items) is 0.926.

Table 2. Reliability Values of Dimensions of the Innovation Quotient Instrument

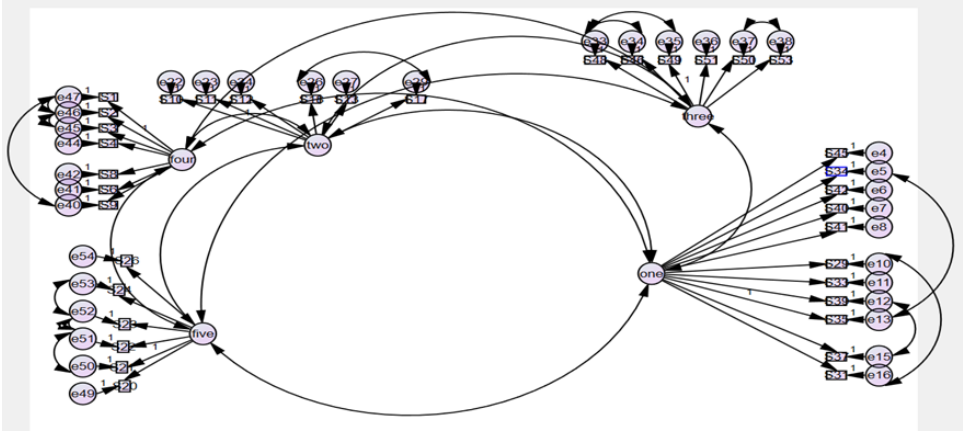
Scales	Cronbach's alpha values
Factor 1-Processes	0,978
Factor 2-Behaviors	0,968
Factor 3-Success	0,950
Factor 4-Values	0,930
Factor 5-Climate	0,929

Since the Cronbach's alpha values of the scale's dimensions are higher than 0.7, the internal consistency of each of them is high.

3.2.5. Confirmatory Factor Analysis (CFA) Results

A confirmatory factor analysis was performed using the exploratory factor analysis data. The goodness of fit values of the instrument were examined after the confirmatory factor analysis;

- CMIN/ df, CFI, and RMSEA values have good fit values
- GFI and AGFI values were found to be acceptable (Table 3)



*S1-S54: 54 items on the scale

Figure 3. Confirmatory Factor Analysis Model for the Innovation Quotient Instrument

As a result of the analysis, the items with a factor load below 0.40 were deleted from the factors to obtain the model's goodness of fit values. When the confirmatory factor analysis model of the instrument is examined after removing the items below 0.40 value, the factor loads of the items of the five dimensions of the scale vary between 0.95 and 0.76.

Table 3. Confirmatory factor analysis model goodness of fit values

Variable	X^2	X^2/df	GFI	CFI	AGFI	RMSEA
Innovation Culture Scale	2191,320	3,838	0,916	0,971	0,913	0,045
Good Fit Values	0≤c2≤2sd	0≤c2/sd ≤2	0.95≤GFI ≤1.00	0.97≤CFI≤1.00	0.90≤AGFI≤1.00	0≤RMSEA≤0.05
Acceptable Value	2sd≤c2≤3sd	2≤c2/sd ≤3	0.90≤GFI≤0.95	0.95≤CFI≤0.97	0.85≤AGFI≤0.90	0.05≤RMSEA≤0.08

After the confirmatory factor analysis, the factor loads and item numbers of the five dimensions of the instrument were changed. Items Q43, Q36, Q44, Q54, Q32, Q27, Q38, Q25, Q19, and Q52 belonging to factor 1 are removed from the factor. Thereafter, the factor loads of the 11 items remaining in Factor 1 ranged from 0.87 to 0.76. Items Q16, Q15, Q14, and Q25 belonging to factor 2 were removed from the factor. It can be seen that the factor loads of the remaining six items of factor 2 vary between 0.95 and 0.77. After the analysis of factor 3, items Q47 and Q30 were removed. It was determined that the factor loads of the remaining six items in factor 3 varied between 0.93 and 0.85. Item Q5 belonging to factor 4 was removed after the analysis, and the factor loads of the remaining seven items were found to vary between 0.87 and 0.73. After subtracting Q7 from the last factor, Factor 5, the factor loads of the remaining six items in the factor were found to vary between 0.76 and 0.86. The final state is shown in Table 4.

Table 4. CFA Factor Loads in the Innovation Quotient Instrument

Factor	Method	Items											p
Factor 1	DFA	Q43	Q36	Q44	Q45	Q34	Q42	Q40	Q54	Q32	Q41	Q27	***
		-	-	-	0,827	0,826	0,860	0,850	-	-	0,829	-	
	DFA	Q29	Q33	Q39	Q35	Q38	Q25	Q31	Q19	Q37	Q52		
		0,820	0,830	0,871	0,762	-	-	0,809	-	0,836	-		
Factor 2	DFA	Q12	Q11	Q10	Q16	Q18	Q13	Q15	Q17	Q14	Q28		***
		0,949	0,921	0,931	-	0,866	0,895	-	0,771	-	-		
Factor 3	DFA	Q47	Q48	Q46	Q49	Q51	Q50	Q53	Q30				***
		-	0,850	0,762	0,866	0,911	0,929	0,855	-				
Factor 4	DFA	Q2	Q3	Q1	Q9	Q6	Q8	Q5	Q4				***
		0,774	0,730	0,837	0,822	0,794	0,874	-	**0,869**				
Factor 5	DFA	Q23	Q22	Q26	Q21	Q24	Q20	Q7					***
		0,765	0,848	0,787	0,856	0,761	0,861	-					
*** *Significant at the p<0.001 level.*													
**** *Q1-Q54: 54 items on the scale*													

When we compared with the original structure, it is seen that two items lessen from the value dimension, three items lessen from the behavior dimension, three items lessen from the climate dimension, four items lessen from the resources dimension, three items lessen from the processes dimension, and finally three items lessen from the success dimension. As in the EFA, the resource dimension has emerged as a more problematic dimension in the CFA.

4. CONCLUSION, DISCUSSION, AND IMPLICATIONS

4.1. Discussion

Although measuring innovation performance in firms is a widely researched area, measuring innovation culture has been a relatively underexplored subject.

While some studies have emerged (Aiman-Smith et al., 2005; Dombrowski et al., 2007; Dobni, 2008; Rao and Weintraub, 2013; Villaluz and Hechanova, 2019), there is a lack of understanding of the measurement items of innovation culture (Michaelis, Aladin, and Pollack, 2018). For example, Dombrowski et al. (2007) included items such as strategy, collaboration, and sustainability in the measurement of culture. On the other hand, Dobni's (2008) and Villaluz and Hechanova's (2019) measurement studies are more culturally oriented. However, considering the literature review we conducted and the relationship of the dimensions with the literature, it is seen that the most appropriate model belonged to Rao and Weintraub's (2013) Innovation Quotient instrument.

In this study, we analyzed exploratory and confirmatory factor analysis and score reliability estimates to examine the construct validity and reliability of six dimensions within the Innovation Quotient instrument (Rao and Weintraub, 2013), which measures innovation culture. The purpose of this study is to reconceptualize and evaluate the validity and reliability of this instrument.

In our study, exploratory and confirmatory factor analysis techniques were used to adapt an innovation culture scale. First, exploratory factor analysis (EFA) was performed. According to the EFA results, the resulting structure was tested with DFA. The results regarding the reliability of the dimensions are then given. Additionally, Cronbach's alpha values were used to test the reliability of the resulting dimensions and scale.

As a result of all these structural validity and reliability analyses, it was determined that the innovation culture in the innovation ecosystem of Turkey can be revealed with five dimensions and 36 items. It is thought that a difference from the proposed scale is the cultural structure and regional innovation ecosystem. Second and more importantly, the lack of a corporate innovation management system in the relevant firm prevented some expert questions from being understood. Third, it was observed that the resource dimension and the process dimension overlapped, and a considerable number of items were eliminated from the resource dimension. Although it is more appropriate to express the resources dimension under the process dimension in this study, when these two dimensions are compared to other dimensions, it can be explained that these two dimensions are more related to innovation input or innovation performance indicators than the cultural indicators of innovation. We can attribute these di-

mensions' overlapping and the items' elimination from the dimensions to these factors.

4.2. Conclusion

As a result, the following main emphasis can be put forward as the most original point of this study: To measure the innovation culture in firms, it should initially analyze how ready the firms are to innovate. Firms that have allocated resources to innovation or have an innovation process (from idea to product) already have a moderate innovation culture. Therefore, to measure innovation culture in a firm, cultural indicators such as the behavior of the managers, the working climate, and the values should be considered first rather than other indicators. Innovation indicators based on input, output, or performance, of course, affect culture or allow the development of culture. However, they might not be essential indicators that need to be initially addressed to measure innovation culture. Compared with other studies, this validated study is the most purified study from these indicators.

The other emphasis we have reached is that measuring innovation culture should be a starting point for a corporate innovation program. Innovation is a crucial element for success in a dynamic and competitive market. The innovation process represents a continuous learning environment that should be sustained and might sometimes be troublesome. Achieving this process requires cultural change. At this stage, creating a corporate culture that supports diversity, creativity, and transformation is essential for successful and sustainable innovation. To reveal the innovation scorecard of firms, we should initially analyze how ready they are to innovate culturally. Before starting a corporate innovation program within a firm, the intention of innovation should first be analyzed. This refers to innovation culture.

4.3. Theoretical implications

The cultural dimension of innovation is not a widely studied subject within innovation management. Although there are some studies on innovation culture, there is not much consensus in the studies on measuring innovation culture. Some studies measure innovation culture with a few items structure, along with studies that examine the dimensions of innovation culture in detail, such as Dobni (2008) and Rao and Weintraub (2013). Therefore, deciding which instrument

to use and analyzing the instrument's measurement accuracy makes the studies in this field unique.

This validated model builds upon many studies by numerous authors. Our literature study and findings support this phenomenon. However, we have shown that the model can be measured with fewer items and a sub-dimension structure. Our literature study and findings support this case. However, due to the above cases mentioned in the Discussion section, the model in our study consisted of fewer factors and sub-items, unlike the proposed model. Thus, we reconsidered a comprehensive innovation culture scale introduced before, validated it, and modestly introduced it into the literature.

4.4. Managerial and practical implications

This study's results can not be seen as just a verification and validation of a scale. Statistical test results provide many insights for managers and innovation professionals. The results provide insights such as the measurement of innovation culture may reveal regional results, some questions may be nonsense for beginners to innovation activities, and cultural and performance-based indicators should not be aligned on the same scale.

The findings of our study indicate some implications for managers regarding the importance of innovation culture. These validated study outputs offer managers a way and attitude to start a corporate innovation program. Corporate innovation efforts can fail if there is no dedication or goodwill toward innovation. The validated innovation culture scale measures the extent of this intent and commitment. Corporate innovation efforts will fail if there is no dedication or goodwill toward innovation. The validated innovation culture scale measures the extent of intent and commitment to innovation. This guide firms in the initial ideal depth of innovation studies.

4.5. Limitations and Future Studies

This study measures innovation culture. We analyzed and validated the instrument using a large sample of one of Turkey's significant defense industry firms. Cultural sub-dimensions were highly correlated and linked in this study and the original study (Rao and Weintraub, 2013). This situation and our analysis show that innovation culture can be measured with fewer sub-dimensions, ques-

tionnaire structure, and items. This situation shows that the innovation culture scale can be perceived as different structures in different countries and cultures. Fewer subdimensions and items emerged because of our analysis. The conditions under which the study was conducted and the regional cultural phenomena may also be effective in this situation. Therefore, conducting validity and reliability studies in different cultural regions is essential.

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Conflict of Interest

No potential conflict of interest was reported by the author(s).

Compliance with ethical standards

For this study, the approval of the Ethics Committee (Name of the Institution) was obtained with the decision dated (Date) and numbered (Number).

The authors declare that the tools and methods used in the study do not require the permission of the Ethics Committee.

Ethical Statement

It was declared by the author(s) that scientific and ethical principles have been followed in this study and that all the sources used have been properly cited.